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ORIGINAL PAPERS

PROGRESS REPORT ON INVESTIGATION OF SAGGER CLAYS—SOME OBSERVATIONS AS TO THE SIGNIFICANCE OF THEIR THERMAL EXPANSIONS.—II[1]

By R. F. Geller and R. A. Heindl

ABSTRACT

This is the second Progress Report based on data obtained in an extensive investigation of sagger clays, conducted for the purpose of determining the properties characterizing clays best suited to this type of service. The report contains a brief description of the apparatus used in the determination of thermal expansion from room temperature to 1000°C together with a correlation of the thermal expansions determined with the physical properties of the clays as given in the first Progress Report. For the clays examined the information obtained indicates that: (*a*) there are two types of clays as characterized by thermal expansion, between 100 and 200°C, and resistance to failure when subjected to sudden temperature changes similar to those encountered in service; (*b*) repeated firings tend to develop increased expansion between 100 and 200°C and, consequently, decreased resistance to failure when subjected to sudden temperature changes; and (*c*) that additions of corundum to clay tend to increase the average, but decrease irregular, thermal expansions.

I. Introduction

In the first Progress Report of this investigation[2] data are given which served as a basis for the grouping or classifying of the fifty-one clays according to their firing characteristics. As stated in the Report, it was proposed to continue the work by a more fundamental study of the clays. Accordingly an apparatus was developed to determine rapidly and with satisfactory accuracy the thermal expansion of specimens sufficiently large to represent adequately commercial bodies. The expansion of forty-nine clays, as well as of several mixtures of

[1] Published by permission of the Director of the U. S. Bureau of Standards, Department of Commerce. Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (White Wares Division.)

[2] *Jour. Amer. Ceram. Soc.*, 9[3], 131–43 (1926).

clays and of clay and corundum, were observed from room temperature to 1000°C.[1]

This paper reports the results of the determinations together with some observations of the expansion characteristics and of the apparent relation of thermal expansion to porosity and resistance to failure in an air-quenching test. For a few clays the effect of repeated firings, and of additions of corundum on thermal expansion was also studied.

II. Description of Specimens

Specimen bars which had previously been fired at 1230°, and broken in determining modulus of rupture, were cemented together, dried at 110°, and a "seating" drilled in each end. The seating was approximately $\frac{5}{8}$ inch deep and of sufficient diameter to form a "loose fit" with the fused quartz rods (Fig. 1) which supported the specimens in the furnace and transmitted the expansion to the gages.

The specimens were about one inch square in cross-section and seven inches long. The distance between the bottoms of the seatings, averaging $5\frac{3}{4}$ inches, was measured to one-thousandth of an inch for each specimen on an end standard comparator, using an Ames gage as an indicator, since it was for this distance (or length of specimen) that the expansions were determined.

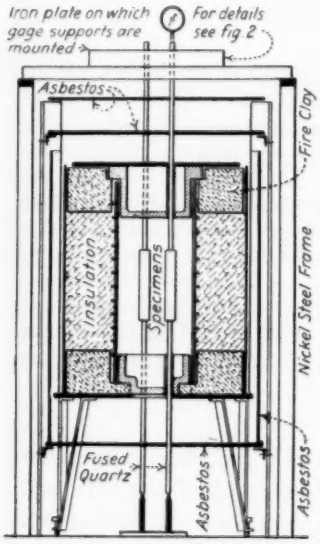

FIG. 1.—Assembly sketch of furnace and apparatus used in the determination of thermal expansions.

The bars were made of 50% clay and 50% grog. The grog in each case was of the same clay as the bond and had been calcined at 1200°C. For the chemical compositions of all the clays, and for the previous thermal history of those clays and bodies used in studying the effect of repeated firings see the first Progress Report.[2]

Since the specimens broke with a clean fracture, in the test for modulus of rupture, the error introduced by the very thin layer of cementing material (sodium silicate) was not considered measurable. The particular specimens previously fired at 1230° were used because the trial saggers used in the quenching test had been fired at this temperature (which is intermediate between the maximum temperatures attained in industrial kilns for semi-vitreous and vitreous ware).

[1] In this Report all temperatures are expressed in degrees C.

[2] *Loc. cit.*, pp. 134 and 141.

III. Description of Apparatus

The construction of the apparatus used in determining expansion coefficients is indicated by the sketch in Fig. 1. It is relatively crude and was not designed for precision measurements.

The furnace proper is of the vertical muffle electrically heated type, the heat being generated in chromel wire coils placed in the upper and lower ends and as a spiral against the outside surface of the muffle. The current to the coils in the ends, and the three units comprising the spiral, can be controlled independently enabling the operator to maintain a satisfactory temperature uniformity.

Three specimens can be observed simultaneously. Each specimen is supported by a fused quartz rod and the expansion is transmitted to a gage (Fig. 1) by another rod of the same material. Asbestos shields, to localize heat radiated from the furnace, are supported on an iron frame not in contact with the furnace and the gages are supported by a third frame, made of nickel-steel. In this way the test specimen and the fused quartz rods, the furnace, the asbestos shields and frame, and the frame supporting the gages can expand and contract independently.

Expansions (or contractions) of $\frac{1}{20,000}$ inch can be read on the gage dials, which were calibrated in the Bureau to this accuracy. A movement of $\frac{16}{10,000}$ inch at the end of the gage lever (Fig. 2) causes the needle to make one revolution of the dial. Since the expansion to be measured usually exceeds $\frac{16}{10,000}$ it was necessary to so mount the gage that it could be raised or lowered, as required, to bring the needle back to zero. The three gages and the method of mounting are shown in Fig. 2.

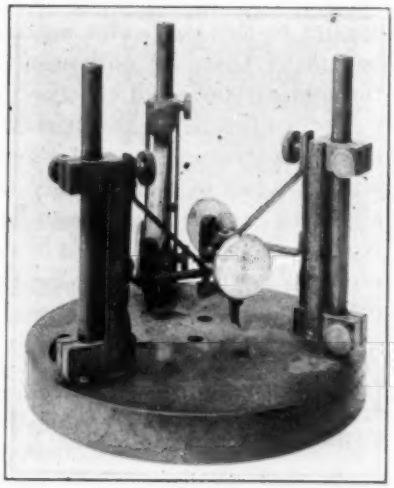

FIG. 2.—Showing method of mounting the gages which were used in measuring thermal expansion.

The set-up of the apparatus and specimens is accomplished by placing the test specimens on the lower fused quartz supports while the top of the muffle, upper asbestos shields, and gage support are removed. The top of the muffle is then replaced and the upper fused quartz rods inserted through the muffle top and into the seatings in the specimens, after which the asbestos shields which protect the gage support and

gages from the heat of the furnace can be laid back on the iron frame. The gage support is then placed on the outer nickel-steel frame and the gages adjusted.

The thermocouples necessary to properly control the temperature within the muffle are admitted through the bottom of the furnace and are semi-permanently installed.

From eight and one-half to nine hours are required to complete a test. In this investigation the temperature was raised quite rapidly through approximately 100-degree intervals and held for about 5 minutes after no further expansion was noted (for typical schedule see Fig. 5).

IV. Calibration

The expansions recorded by the gages (Figs. 1 and 2) are not the direct expansions of the test specimens but the total expansions of the specimens, the fused quartz rods, and the supports for the gages. The correction curve (or constant) for the apparatus was determined by observing the total expansion using three fused quartz specimens whose true expansion was known[1] (from room temperature to 1000°) and calculating the difference between the observed expansion and the known true expansion of the specimens alone. Since the curve applies to this particular apparatus only, it is not shown but it may be stated that the correction averaged approximately 10% of the thermal expansion of the specimens as determined in this work.

The calibrated apparatus was used in testing materials whose thermal expansions varied from that of fused quartz to that of fused alumina, and in a laboratory in which the temperature varied from about 18° at the beginning of the test to 26° at the end of the test. No data have been obtained to show the probable accuracy for materials of greater or lesser expansion than those tested, or when made under other conditions of room temperature.

V. Precision

1. Observations on Heating

The accuracy of the calibrated apparatus was determined by measuring the expansion of specimens of porcelain and zirconium silicate and comparing the results with results obtained in the Thermal Expansivity and Interferometry Sections of the Bureau.[2] It was found that the

[1] See forthcoming Bur. of Stand., *Sci. Paper*, No. 524, "Measurements of the Thermal Expansion of Fused Silica."

[2] The method used in the Thermal Expansivity Section will be described in the forthcoming Scientific Paper referred to in above footnote . The method used in the Interferometry Section is described by Peters (*Jour. Wash. Acad. Sci.*, 9[10], 281 (1919)) and Merritt (Bur. of Stand., *Sci. Paper*, No. 485). See also G. E. Merritt and C. G. Peters, "Interferometer Measurements of the Thermal Dilatation of Glazed Ware," *Jour. Amer. Ceram. Soc.*, 9[6], 327–42 (1926).

maximum average variation in coefficient of expansion for a two-hundred degree temperature range was 0.2×10^{-6} per degree C, which is equivalent to an accuracy of approximately $\pm 2.5\%$. The data are summarized in Table I and shown in Figs. 3 and 4.

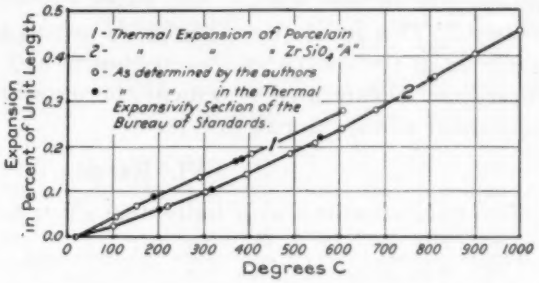

FIG. 3.—Curves showing agreement of results obtained in this investigation with results obtained in the Thermal Expansivity Section of the Bureau of Standards on the same material.

The temperature uniformity within that area of the furnace occupied by the specimens was observed by means of nine base metal thermocouples, one couple being placed at the bottom, one at the top, and one midway of each specimen. The temperatures were recorded to the nearest $\frac{1}{4}$ millivolt (equivalent to the nearest 6°) and the current to the heating coils was so controlled that the temperature gradient, as observed by the nine couples, did not exceed 12°. The temperature record of a typical test is given in Table II and the maximum and minimum temperatures for this test are shown by the two curves in Fig. 5.

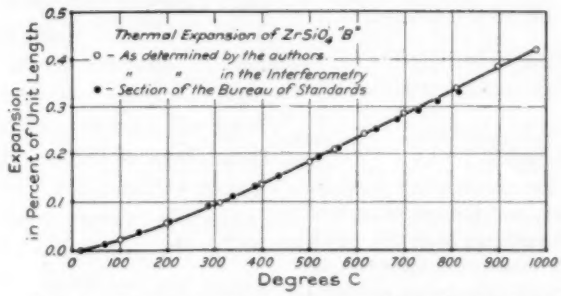

FIG. 4.—Curves showing agreement of results obtained in this investigation with those obtained in the Interferometry Section of the Bureau of Standards on the same material.

2. Observations on Cooling

It was found to be impossible to control the temperature during cooling within the area occupied by the specimens to closer than 30°. Consequently, the accuracy of observations on cooling is less than on heating. Under these conditions the plotted values obtained on cooling zircon and fused quartz practically followed the expansion curves on heating but dropped below those for the clays in the range from 600 to 300°. This showed an appreciable change in rate of expansion due to the $\alpha \leftrightarrows \beta$ quartz inversion.

Observations were taken following a number of the tests, and after the apparatus had reached equilibrium at room temperature, to deter-

mine whether or not the gages would come back to zero. With the exception of clay Number 39, which showed a slight permanent contraction (about 0.1%), the gages came back to within $\frac{5}{10,000}$ of zero. This indicates a negligible permanent expansion (or contraction) in the length of the specimens and also demonstrates that the sodium silicate used to cement the pieces produced no noteworthy permanent change during the tests.

VI. Results

The data obtained with individual clays fired at 1230°C are given in Tables III and IV. Typical curves are shown in Figs. 6, 7, and 8. As is evident, the curves have been grouped according to the thermal expansion behavior from 100 to 200°; clays of Group L (Table III and Figs. 6 and 7) showed a decided increase in the rate of expansion while clays of Group H (Table IV and Fig. 8) showed a very small or, in the majority of cases, no increase in rate of expansion.

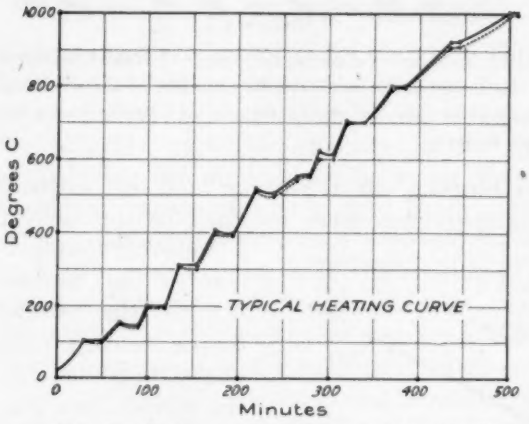

FIG. 5.—During each test temperature readings were taken at top, midway, and bottom of each of the three specimens. The two curves in this figure show the maximum and minimum temperatures recorded by the nine thermocouples during a typical test.

TABLE I.

(1) Observations obtained with apparatus described in this paper
(2) Observations obtained in Thermal Expansivity Section
(3) Observations obtained in Interferometry Section

Average Coefficient of Expansion $\times 10^{-6}$

Temp. Range	Room temp. to 200°		200°–400°		400°–600°		600°–800°		Room temp. to 800°	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Porcelain	5.2	5.2	4.2	4.4	5.1	4.9	—	—	—	—
Zircon "A"[a]	3.4	3.3	4.1	4.1	5.0	5.1	5.2	5.1	4.4	4.4
	(1)	(3)	(1)	(3)	(1)	(3)	(1)	(3)	(1)	(3)
Zircon "B"[b]	3.2	3.2	4.1	4.1	4.9	4.9	5.0	5.2	4.3	4.2

[a] Zircon "A" (Fired to 1450°C)—$\begin{cases} \frac{2}{3} - \text{100-mesh zircon} \\ \frac{1}{3} - \text{200-mesh zircon} \end{cases}$

[b] Zircon "B" (Fired to 1485°C)—Zircon "A" bars crushed and ground to pass an 80-mesh sieve.

TABLE II

Temperature Readings Taken during a Typical Run and Showing Temperatures at Top, Midway, and Bottom of Each of the Three Specimens.

Time in minutes	Specimen A			Specimen B			Specimen C		
	Top °C	Mid °C	Bot °C	Top °C	Mid °C	Bot °C	Top °C	Mid °C	Bot °C
30	103	103	103	103	103	103	103	103	103
50	103	103	103	103	103	98	103	103	103
70	150	155	150	150	150	150	150	150	150
90	144	144	144	144	138	144	144	144	144
100	199	199	194	199	199	199	199	199	199
120	194	199	199	199	194	199	199	194	199
135	304	311	304	304	304	304	304	304	311
155	311	311	297	311	304	311	311	311	297
175	407	407	401	407	407	407	407	407	395
195	389	395	389	395	389	395	395	395	389
220	511	517	511	517	517	517	517	517	511
240	500	505	500	505	494	505	505	500	500
265	546	552	540	552	546	546	546	546	546
280	558	558	552	558	558	558	558	558	552
290	611	617	599	611	605	605	605	605	599
305	605	611	599	611	599	605	605	605	599
330	700	705	694	700	700	700	700	700	700
350	700	700	700	700	700	700	700	700	700
380	795	801	789	795	795	795	795	795	789
395	795	801	795	801	795	801	801	795	801
445	906	919	906	906	912	906	906	906	906
455	906	919	906	906	919	912	912	906	906
505	995	1001	989	995	995	995	995	989	995
515	995	1001	995	1001	995	995	995	995	995

1. Characteristics of Curves

(a) From Room Temperature to 100°

For Group L the expansion in this temperature range varied from 0.04 to 0.08%, and for Group H from 0.02 to 0.06%. Although the inversions of tridymite ($\alpha \rightarrow \beta$, 117°C; $\beta_1 \rightarrow \beta_2$ 163°C)[1] take place above 100°C, there appears to be a relation between expansions considerably below 100° and expansions from 100° to 200° for it is evident from the data that the expansions from room temperature to 100° are,

[1] C. N. Fenner, *Amer. Jour. Sci.*, **36**, 331–84 (1913).

generally, directly proportional to the expansions from 100° to 200°.

(b) From 100 to 200° The expansion for all clays of Group H was very nearly the same (approximately 0.06%) in this range (Fig. 8), but varied greatly with clays of Group L. In the latter group, clay No. 18 expanded 0.08% and clay No. 3 expanded 0.27%, while the majority varied between 0.10 and 0.16% and the average for the group is approximately 0.14%.

While there are no known inversions in this range (100°–200°) other than those of tridymite to account for observed changes in rate of expansion, microscopic examinations have failed to show the presence of tridymite.[1]

(c) From 200 to 300° The expansions observed in this range are again practically the same for all clays of Group H (No. 45 excepted)[2] and vary considerably for clays of Group L. Four clays of Group L (Nos. 3, 6, 20, and 23), and clay 45 of Group H, expanded more rapidly between 200 and 300° than between 300 and 500° indicating the presence of cristobalite. The other clays of Group H, which expanded uniformly (or practically so) from 100 to 500°, probably contained neither tridymite nor cristobalite; and the balance

---

[1] The following evidence for and against the presence of tridymite is offered for the reader's consideration (H. Insley, collaborator):

For 1. The inversions of tridymite are known to occur between 100 and 200° (Fenner *loc. cit.*).

2. There are no other known inversions in this range.

3. After repeated firings the expansion due to the $\alpha \rightleftarrows \beta$ quartz inversion is diminished (see Fig. 7) while the expansion between 100 and 200° is increased.

Against 1. Microscopic examination by two petrographers failed to show the presence of tridymite.

2. Braesco (*Annales de Physiques*, **14**, 5 (1920)) as well as Le Chatelier (La Silica, Revue, **1**, 20 (1913)) show curves which indicate that the expansion caused by the $\alpha \rightarrow \beta$ quartz inversion is 2 to 3 times as large as the expansions caused by tridymite inversions. In many of the curves shown in this report (Figs. 3, 4, and 5) the expansion between 100 and 200° exceeds that between 500 and 600°. The quantity of tridymite in these specimens must therefore be at least twice as great as the quantity of quartz. If this is true, it should certainly be observable microscopically; furthermore, such quantities of uncombined SiO_2 cannot be accounted for from the chemical compositions.

3. Appreciable cristobalite could certainly be expected in a body containing tridymite (except after very long heating or in the presence of certain fluxes) since it is always an intermediate product in the inversion of quartz to tridymite. Yet the expansion curves of only 5 clays (Nos. 3, 6, 20, 23, and 45) clearly indicate the presence of cristobalite. This fact suggests the further possibility that the inversion of cristobalite may be partly or wholly depressed below 200°C in clay bodies and, since it causes an expansion six or more times greater than the tridymite inversions, could easily account for the phenomenon observed.

[2] Clay 45 is unique in that it is the only clay investigated showing a markedly greater expansion from 200 to 300° than from 100 to 200°.

of the clays of Group L, which expanded practically uniformly from 200 to 500°, probably contained no cristobalite (see footnote, p. 570).

(d) From 300 to 500° No known inversions of SiO_2 occur in this range and it is noteworthy that the rate of expansion is nearly the same for all the clays tested. The total expansion varied from 0.100 to 0.140% and averaged approximately 0.115%. Expressed as the coefficient (per cent per degree C), this average value is 0.0000057 (which checks with results of previous investigators as summarized by A. B. Searle*). Since many clays of Group H expanded at approximately this rate (57×10^{-7}) from 100 to 1000°, and clays of Group L from 200 to 1000° this value is probably the average coefficient of expansion of sagger clay when unaffected by inversions of uncombined SiO_2.

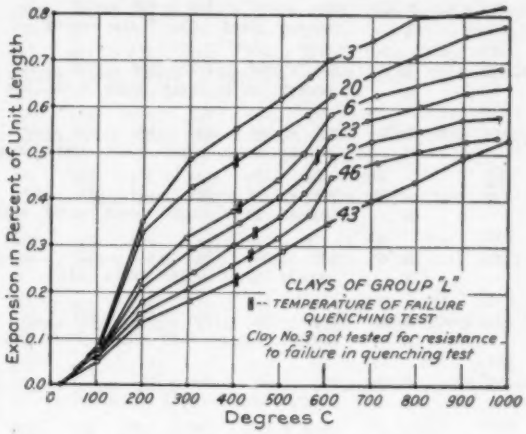

FIG. 6.—Thermal expansion curves of clays typical of Group L.

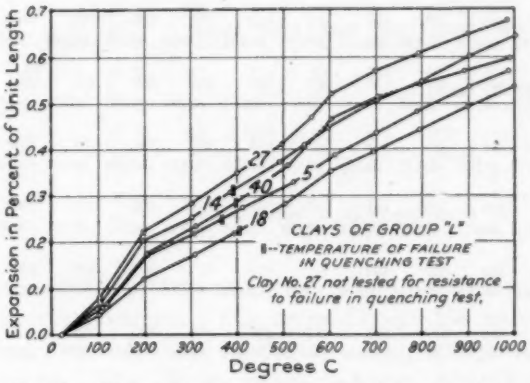

FIG. 7.—Thermal expansion curves of clays typical of Group L.

(e) From 500 to 600° The inversions of $\alpha \rightleftarrows \beta$ quartz[1] are probably the most generally known and discussed "expansion phenomena" in the ceramic industry. Approximately one half of the clays investigated showed a considerable increase in rate of expansion when heated

* The Chemistry and Physics of Clays, pp. 570–573.

[1] F. J. Bates and S. M. Phelps, of the Polarimetry Section of the Bureau of Standards report the $\alpha \rightarrow \beta$ quartz inversion at 573.3°, and the $\beta \rightarrow \alpha$ quartz inversion as less sharply defined but probably between 572 and 573°.

TABLE III

DETAILED DATA GIVING THERMAL EXPANSIONS, AND TEMPERATURES AT WHICH OBSERVED, FOR CLAYS OF GROUP L

Clay No. A. Temperature at which expansion was determined, in °C
B Observed expansion, per unit length, at temperature indicated.

Clay No.												
1	A °C	108	199	310	408	511	—	610	698	789	896	1015
	B	.000536	.00146	.00205	.00246	.00349	—	.00449	.00482	.00510	.00555	.00587
2	A °C	103	199	312	399	501	553	615	699	808	897	978
	B	.000641	.00177	.00242	.00301	.00364	.00415	.00494	.00526	.00550	.00575	.00580
3	A °C	104	198	303	401	498	563	606	700	794	901	986
	B	.000823	.00351	.00488	.00555	.00619	.00667	.00705	.00746	.00796	.00803	.00817
4	A °C	103	198	303	403	492	551	600	708	794	915	1000
	B	.000648	.00225	.00287	.00344	.00390	.00431	.00478	.00534	.00568	.00614	.00633
5	A °C	120	207	307	412	523	—	612	702	790	903	989
	B	.000672	.00173	.00219	.00274	.00329	—	.00387	.00433	.00478	.00533	.00566
6	A °C	104	195	296	397	495	551	610	709	800	896	982
	B	.000667	.00222	.00319	.00375	.00443	.00500	.00586	.00628	.00650	.00673	.00687
7	A °C	119	200	304	407	511	—	608	701	794	894	1001
	B	.00074	.00215	.00273	.00330	.00391	—	.00486	.00543	.00555	.00587	.00626
8	A °C	103	198	303	403	492	551	600	708	794	915	1000
	B	.000576	.00198	.00246	.00318	.00370	.00406	.00433	.00481	.00538	.00590	.00623
9	A °C	103	198	303	403	492	551	600	708	794	915	1000
	B	.000656	.00182	.00229	.00274	.00321	.00353	.00381	.00456	.00498	.00554	.00594
10	A °C	102	194	305	392	481	554	612	699	801	896	993
	B	.000585	.00232	.00284	.00332	.00381	.00430	.00478	.00515	.00556	.00597	.00624
11	A °C	104	195	296	397	495	551	610	709	800	896	982
	B	.000737	.00186	.00228	.00280	.00335	.00375	.00408	.00463	.00510	.00549	.00582
12	A °C	105	197	303	387	493	547	598	704	800	904	1005
	B	.000619	.00195	.00239	.00284	.00339	.00371	.00402	.00459	.00505	.00562	.00605
13	A °C	105	197	303	387	493	547	598	704	800	904	1005
	B	.000625	.00218	.00282	.00327	.00390	.00447	.00479	.00525	.00558	.00603	.00629
14	A °C	105	197	303	387	493	547	598	704	800	904	1005
	B	.000696	.00203	.00253	.00307	.00371	.00408	.00444	.00502	.00543	.00597	.00641
16	A °C	103	203	310	395	499	—	615	711	809	894	1002
	B	.000771	.00258	.00315	.00359	.00416	—	.00480	.00532	.00585	.00624	.00674
17	A °C	109	197	312	411	498	552	609	689	805	906	999
	B	.000537	.00164	.00202	.00247	.00296	.00325	.00361	.00409	.00460	.00508	.00550
18	A °C	103	199	310	395	505	—	605	696	795	900	1001
	B	.000437	.00121	.00172	.00217	.00281	—	.00351	.00392	.00438	.00487	.00531
20	A °C	105	198	307	400	495	557	612	701	795	904	988
	B	.000807	.00326	.00427	.00482	.00546	.00585	.00627	.00674	.00711	.00757	.00777
22	A °C	105	198	307	400	495	557	612	701	795	904	988
	B	.000711	.00169	.00215	.00256	.00306	.00340	.00383	.00416	.00455	.00479	.00507

TABLE III (*Concluded*)

Clay No.	A. Temperature at which expansion was determined, in °C B. Observed expansion, per unit length, at temperature indicated.											
23	A °C	109	197	312	411	498	552	609	689	805	906	999
	B	.000709	.00208	.00295	.00350	.00407	.00450	.00537	.00572	.00604	.00635	.00647
25	A °C	109	197	312	411	498	552	609	689	805	906	999
	B	.000776	.00207	.00234	.00285	.00338	.00369	.00405	.00455	.00512	.00566	.00608
27	A °C	104	198	303	401	498	563	606	700	794	901	986
	B	.000806	.00222	.00284	.00349	.00410	.00467	.00519	.00566	.00604	.00646	.00675
28	A °C	106	195	299	398	496	555	604	699	805	909	999
	B	.000757	.00188	.00223	.00284	.00338	.00370	.00403	.00456	.00509	.00565	.00597
29	A °C	106	195	299	398	496	555	604	699	805	909	999
	B	.00070	.00224	.00303	.00360	.00431	.00475	.00533	.00576	.00613	.00643	.00662
30	A °C	103	203	310	395	499	—	615	711	809	894	1002
	B	.000615	.00184	.00253	.00300	.00369	—	.00518	.00556	.00592	.00617	.00651
31	A °C	110	209	300	401	504	556	604	704	790	893	1000
	B	.000688	.00162	.00200	.00246	.00297	.00325	.00362	.00411	.00449	.00498	.00539
40	A °C	108	206	311	401	512	—	605	705	795	893	991
	B	.000602	.00176	.00234	.00287	.00365	—	.00464	.00510	.00539	.00566	.00593
41	A °C	103	202	305	394	491	547	604	686	811	898	1000
	B	.000695	.00239	.00298	.00353	.00424	.00469	.00521	.00563	.00617	.00657	.00690
43	A °C	103	196	304	407	506	—	606	700	795	899	1000
	B	.000492	.00135	.00181	.00228	.00289	—	.00349	.00398	.00439	.00490	.00530
44	A °C	107	198	304	400	496	567	607	704	805	912	1002
	B	.000515	.00147	.00198	.00244	.00293	.00334	.00359	.00401	.00455	.00510	.00545
46	A °C	107	195	301	397	495	564	611	712	803	906	974
	B	.000616	.00153	.00208	.00257	.00318	.00367	.00449	.00483	.00506	.00529	.00536
48	A °C	107	195	301	397	495	564	611	712	803	906	974
	B	.000524	.00129	.00172	.00222	.00287	.00329	.00381	.00424	.00453	.00496	.00529
49	A °C	108	206	311	401	512	—	605	705	795	893	991
	B	.000625	.00181	.00232	.00287	.00354	—	.00453	.00496	.00536	.00572	.00614
50	A °C	114	188	310	395	511	—	606	700	801	900	1001
	B	.000694	.00180	.00249	.00295	.00353	—	.00456	.00505	.00550	.00597	.00640

from 500 to 600° and this can undoubtedly be attributed to the $\alpha \rightarrow \beta$ quartz inversion. For several clays the expansion from 500 to 550°, and from 550 to 600°, was also determined. For some clays the curves (Nos. 19, 46, and 48) showed plainly that the increased rate of expansion was restricted to the range 550–600°. Other curves (Nos. 2, 6, 23, and 27) showed equally plainly that the increase in rate of expansion started below 550°. This indicates that the inversions of quartz combined with clay may or may not take place (or at least appear to take place) within a rather definite temperature range, being

TABLE IV

DETAILED DATA GIVING THERMAL EXPANSIONS, AND TEMPERATURES AT WHICH OBSERVED, FOR CLAYS OF GROUP H

Clay No.		A. Temperature at which expansion was determined in °C. B. Observed expansion per unit length at temperature indicated.										
15	A °C	103	194	314	409	511	—	604	704	795	879	988
	B	.000379	.000826	.00137	.00180	.00253	—	.00340	.00377	.00402	.00428	.00456
19	A °C	104	197	302	405	503	556	603	706	798	908	999
	B	.000440	.00122	.00175	.00230	.00296	.00325	.00429	.00476	.00495	.00522	.00536
21	A °C	105	198	307	400	495	557	612	701	795	904	988
	B	.000546	.00121	.00183	.00223	.00271	.00303	.00331	.00374	.00413	.00463	.00484
24	A °C	103	194	314	409	511	—	604	706	795	879	988
	B	.000588	.00113	.00160	.00200	.00255	—	.00339	.00385	.00418	.00460	.00492
26	A °C	119	200	304	407	511	—	608	701	794	894	1001
	B	.00047	.00099	.00150	.00208	.00278	—	.00398	.00434	.00456	.00487	.00523
32	A °C	120	207	307	412	523	—	612	702	790	903	989
	B	.000323	.000677	.00110	.00169	.00232	—	.00303	.00341	.00375	.00421	.00430
35	A °C	120	207	307	412	523	—	612	702	790	903	989
	B	.000357	.000769	.00115	.00167	.00222	—	.00288	.00326	.00364	.00420	.00459
36	A °C	103	196	304	407	506	—	606	700	795	899	1000
	B	.000373	.000839	.00132	.00187	.00252	—	.00327	.00374	.00426	.00495	.00542
37	A °C	103	199	310	395	505	—	605	696	795	900	1001
	B	.000367	.000954	.00167	.00225	.00304	—	.00391	.00439	.00496	.00572	.00629
38	A °C	106	194	313	391	505	—	628	705	795	897	993
	B	.000426	.000726	.00155	.00180	.00276	—	.00365	.00397	.00430	.00477	.00520
39	A °C	113	200	307	406	510	—	599	712	799	900	999
	B	.000429	.000840	.00137	.00176	.00220	—	.00276	.00339	.00363	.00399	.00431
42	A °C	98	197	313	400	495	544	605	705	808	904	997
	B	.000292	.00095	.00147	.00193	.00252	.00292	.00386	.00417	.00443	.00466	.00480
45	A °C	103	203	310	395	499	—	615	711	809	894	1002
	B	.000571	.00117	.00232	.00278	.00346	—	.00457	.00509	.00556	.00589	.00626
47	A °C	107	195	301	397	495	564	611	712	803	906	974
	B	.000393	.000881	.00131	.00179	.00238	.00279	.00326	.00369	.00405	.00460	.00495
51	A °C	103	197	307	392	501	557	605	700	798	910	996
	B	.000323	.000903	.00137	.00182	.00235	.00278	.00338	.00359	.00380	.00406	.00415

probably controlled by the previous thermal and geological history of the quartz and the clay of which it forms an integral part.

(f) From 600 to 1000° The curves for many of the clays (Ex. 2 and 23) show a gradually decreasing rate of expansion as the temperature is raised from 600 to 1000°. In general this decrease in rate is proportional to the increased expansion between 500 and 600°, which may be the combined effect of expanding

clay and contracting quartz[1] since there was no measurable decrease in the case of clays whose expansion curves indicated the absence of quartz.

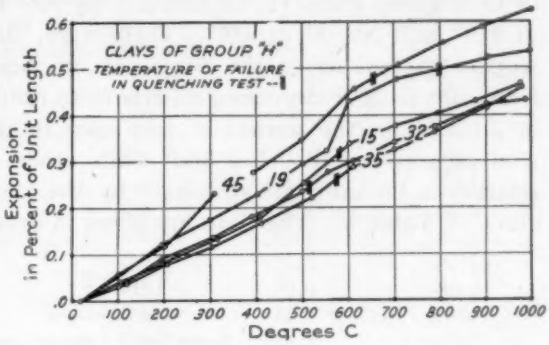

FIG. 8.—Thermal expansion curves of clays typical of Group H.

The curves and data presented show many interesting relations, but it is evident that a more thorough understanding of their significance, particularly in the range from room temperature to 300°, will necessitate expansion determinations at less than one-hundred degree intervals. It might also be advisable to study synthetically prepared bodies containing known quantities of practically pure clay matter, tridymite, and cristobalite.

2. Expansion vs. Resistance to Failure in Quenching Test

While the quenching test referred to in the subtitle has been described in the first report[2] it might be well to outline again the method of procedure; five specimen saggers of each clay were air-quenched at progressively higher temperatures until fracture occurred. The initial furnace temperature was 350°C, the second 400°C, and for each succeeding test the temperature was increased 25°C until 800°C was reached. A satisfactory series of comparative results was obtained. It was found that a majority of the saggers fractured at or below 575°C. Saggers of one clay (No. 16), which is bauxitic, were still perfect at 800 and the test was continued to 1000°C, at which temperature no saggers had failed and the test was discontinued.

Of the forty-six clays submitted to the quenching test, thirty-two are of Group L (Table III) and fourteen of Group H (Table IV). With only five exceptions (Nos. 11, 16, 22, 23, and 30) all the clays of Group L failed in the quenching test *below* 500° while, of Group H, all the clays (one excepted, No. 37) failed *above* 500°; of these ex-

[1] Previous investigators (C. N. Fenner, *loc. cit.*, and H. Insley, *loc. cit*) have shown that β quartz decreases in volume when heated above the inversion temperature.

[2] *Loc. cit.*, p. 138. This test was designed to simulate the sudden temperature changes to which a sagger is subjected when a kiln is opened and when the hot sagger is moved to the open air.

ceptions only three differ radically in their behavior from the rest of their group (Nos. 11, 16, and 23) for No. 22 failed at 505°, No. 30 at 510°, and No. 37 at 480°. There were, therefore, only three noteworthy exceptions to the rule that an increased rate of expansion from 100 to 200° decreases resistance to failure when suddenly cooled in air and, in the particular test used in this investigation, caused trial saggers to fail below 500° while others failed above 500°. The relation is brought out strikingly by the averages for the Groups as given in Table V. The data are given in detail in Table VI.

TABLE V

Group Averages

	Average temperature of failure in air-quenching test	Average porosity of specimens fired at 1230°C	Average expansion from 100° to 200°
	°C	%	%
Group L	436	31	0.139
Group H	606	24	0.057

While the average total expansion of clays of Group L, from room temperature to 1000°, is roughly 0.001 per unit length higher than that of Group H, it should be noted that this difference is caused by the greater expansion of Group L clays below 200°.

Whether the quenching test used in this investigation will determine the relative life of a sagger under plant conditions, or not, remains to be demonstrated. In any case it is believed that the relation between expansion from 100 to 200° and behavior in the quenching test is sufficiently definite to be of fundamental significance and worthy of consideration in connection with plant practice. In cooling a kiln it is generally considered safe to tear down the wickets after the kiln is "black" and permit the cooling to proceed as rapidly as possible, the argument being that the ware has safely passed the "quartz inversion"[1] and is therefore not liable to be harmed. The data presented here clearly show that there is not only a greater expansion from room temperature to 500° than from 500 to 1000°, but that for many clays the expansion rate may be very high at temperatures which are referred to as merely "warm" (100–200°). Furthermore it is indicated that the expansion behavior in this low range materially affects the life of the sagger. It would appear advisable then either to cool with greater care at these low temperatures, or to choose

[1] The transition from a visible (low red) heat to an invisible (black) heat is naturally gradual but in practice is considered to take place at approximately 500°C. As previously stated, the $\alpha \leftrightarrows \beta$ quartz inversions occur at approximately 573.0°C.

TABLE VI

DATA PRESENTED TO SHOW THE RELATION BETWEEN MODULUS OF RUPTURE (COLD), TEMPERATURE OF FAILURE IN THE QUENCHING TEST, POROSITY, AND THERMAL EXPANSION BETWEEN 100 AND 200°

Clay No.	Group	Modulus of rupture of specimens fired at 1230°C Lbs. per sq. in.	Temp. of failure in air-quenching test °C	Porosity of specimens fired at 1230°C %	Expansion from 100° to 200° % per 1°C
1	L	2890	405	19.7	.00101
2	L	1570	445	34.1	.00118
4	L	1360	420	25.1	.00189
5	L	3165	370	15.7	.00122
6	L	734	410	35.0	.00170
7	L	1265	440	30.0	.00174
8	L	2420	405	32.2	.00147
9	L	2655	420	23.3	.00122
10	L	1980	420	22.3	.00199
11	L	1655	535	40.8	.00123
12	L	2165	400	25.5	.00145
13	L	1680	390	31.0	.00168
14	L	2277	390	29.3	.00145
15	H	3670	580	20.0	.00054
16	L	620	over 1000	39.0	.00211
17	L	2695	475	32.1	.00125
18	L	3650	405	20.4	.00080
19	H	1055	800	37.6	.00084
20	L	1380	400	32.3	.00264
21	H	2060	540	21.6	.00071
22	L	2490	505	27.4	.00105
23	L	615	580	30.2	.00156
24	H	3055	570	26.5	.00059
25	L	3290	495	27.7	.00147
26	H	2280	590	23.7	.00064
28	L	3090	415	22.8	.00126
29	L	2615	400	22.5	.00178
30	L	860	510	40.0	.00123
31	L	770	495	38.2	.00094
32	H	3225	515	10.1	.00041
35	H	3000	575	19.1	.00047
36	H	2910	545	13.0	.00050
37	H	5350	480	8.1	.00061
38	H	3060	535	21.8	.00034
39	H	3700	565	25.7	.00047
40	L	2510	400	32.6	.00098
41	L	3110	350	33.5	.00171
42	H	1500	745	27.6	.00067
43	L	2470	405	26.0	.00092
44	L	2525	490	27.5	.00105
45	H	3380	655	29.3	.00060
46	L	1105	435	38.0	.00102
48	L	3690	455	25.5	.00088
49	L	2300	460	27.6	.00121
50	L	2330	425	26.2	.00150
51	H	1055	770	23.5	.00062

sagger clays of minimum expansion and contraction[1] below 300°, *i.e.*, clays of the Group H type.

3. Effect of Porosity

The porosities of the specimens used in determining thermal expansion are given in Table VI and averaged, for the groups, in Table V. For the convenience of the reader they were also plotted (Fig. 9) against "temperature of failure in quenching test." Whether the relation indicated by Fig. 9 and the averages (Table V) are significant, or merely incidental to thermal expansion, is not known. However, it may be of interest that the resistance to failure in quenching *for clays of Group H* is roughly directly proportional to increase in porosity.

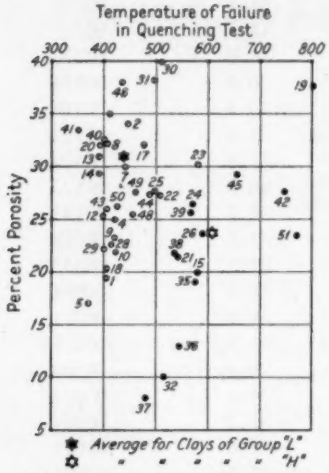

FIG. 9.—Showing the relation between porosity and temperature of failure in the quenching test. The data indicate that, for clays of Group H, the resistance to failure in the quenching test is proportional to porosity.

That this relation should exist for clays of Group H and not for clays of Group L can be accounted for by assuming that porosity becomes a factor only when no marked increase in rate of expansion takes place between 100 and 200° and, consequently, no "expansion strains" are introduced to overcome the effect of porosity. (The same assumption would hold with regard to the indicated relation between the modulus of rupture and resistance to failure in the quenching test for clays of Group H, see VI, 4.)

4. Effect of Fired Strength (Modulus of Rupture)

The moduli of rupture of the specimens used in determining thermal expansion are given in Table VI. It is indicated that the resistance to failure in quenching *for clays of Group H* is inversely proportional to strength (modulus of rupture). However, the relation is not as well defined as in the case of porosity (discussed above). The elasticity

[1] The curves and data presented were obtained with rising temperatures, but it was demonstrated with clays of Group L that contractions with falling temperatures practically followed the same curves below 300°. A rising temperature was used because of the greater convenience in maintaining a definite temperature-time schedule.

and modulus of rupture of the clays will be determined at the temperature of failure in the quenching test and it is believed that the information to be obtained in this way will have a more direct bearing on the problem of determining the influence of strength on the life of saggers.

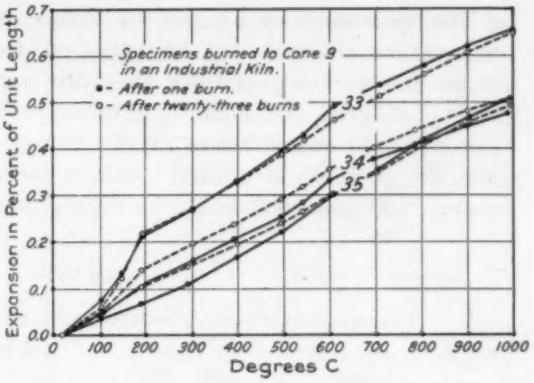

FIG. 10.—Thermal expansion curves showing the effect of repeated firings on thermal expansion. In general the data indicate that repeated firings lower the thermal expansion between 500 and 600° and increase the expansion between 100 and 200°.

5. Expansion as Affected by Repeated Firing

As stated in Section II, the composition and previous thermal history of the specimens used in this study are given in the first Progress Report, p. 141. In brief, the specimens were made of a mixture of 75% raw clay (or mixture of clays) and 25% grog of the same clay (or the same mixture of clays). Clays 11 and 12, and body 101 (an equal mixture of 11 and 12), were fired from one to seventeen times at cone 11. Clays 33, 34, and 35, and body 345 (an equal mixture of 33, 34, and 35), were fired from one to 26 times at cone 9.

The data (Table VII and Fig. 10) show that repeated firings lower the expansion between 500 and 600° and increase the expansion between 100 and 200°, indicating that the quartz initially present converts to another form of silica. In no case is there greater expansion from 200 to 300°, than from 300 to 400° to indicate the presence of cristobalite.[1]

Since repeated firings apparently tend to increase the 100 to 200° expansion, and since the data reported indicate this expansion to be a controlling factor in the life of saggers, it may be stated that,

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[1] H. S. Houldsworth and J. W. Cobb (*Jour. Amer. Ceram. Soc.*, **6**[5], 645 (1923)) using an apparatus described by Boeck (*Trans. Amer. Ceram. Soc.*, **14**, 470 (1912)) observed an increased rate of expansion between 100 and 200° for Ayrshire bauxitic clay and Farnley fire clay, fired at cones 9 and 14, but not between 200 and 300°. The same phenomenon was noted by G. E. Merritt for Florida kaolin (Bur. Stand., *Sci. Paper*, No. 485, p. 368).

(*a*) the resistance of saggers to failure when subjected to sudden temperature changes can be expected to decrease with prolonged use no matter how carefully they are handled;[1] (*b*) the use of "old grog" (*i.e.*, grog obtained by grinding brick or saggers which have been reheated many times in the course of service) is detrimental since the possible structural changes evidenced by large expansion between 100 and 200° would be highly developed.

TABLE VII

THERMAL EXPANSION OF SPECIMENS FIRED IN COMMERCIAL KILNS

Clay No.	100°C to 200°C after		500°C to 600°C after		Clay No.	100°C to 200°C after		500°C to 600°C after	
	1 firing	17 firings	1 firing	17 firings		1 firing	23 firings	1 firing	23 firings
	%	%	%	%	33	0.155	0.181	0.083	0.063
11	0.127	0.161	0.060	0.053	34	0.070	0.102	0.073	0.061
12	0.154	0.167	0.073	0.065	35	0.036	0.065	0.075	0.055
101	0.150	0.160	0.060	0.047	345	0.065	0.115	0.068	0.061

6. Effect of Corundum on Thermal Expansion of Clay

The results obtained by determining the effects on thermal expansion of additions of artificial corundum to two sagger clays are shown in Figs. 11 and 12. For reference the thermal expansion of the corundum used was determined and is shown in Fig. 11.[2] The curves of clay No. 42 (curve 42, Fig. 11) and clay No. 25 (curve 25, Fig. 12) were plotted from the data given in Tables I and II. The mixtures used are given in Table VIII.

TABLE VIII

BODIES USED IN STUDYING EFFECT OF CORUNDUM ON THERMAL EXPANSION

	Per Cent by Volume				
	Clay No. 25		Clay No. 42		Corundum
Specimen No.	Raw	Calcined	Raw	Calcined	
25 A	50	25	—	—	25
25 B	40	—	—	—	60
42 A	—	—	50	25	25
42 B	—	—	40	—	60

The effect of the corundum is so evident from the curves as to require little discussion. Specimens of clay No. 42 (containing 70.2%

[1] Data given in the first Progress Report (*loc. cit.*) on page 141 indicate that repeated firings will not decrease the transverse strength of sagger bodies at room temperature.

[2] The corundum and corundum and clay specimens were prepared by M. F. Beecher, of the Norton Company, using clays furnished by the Bureau.

SiO_2) underwent a slight increase in rate of expansion from 100 to 200° and a marked increase when heated from 540 to 600°. These irregularities were almost entirely removed by using 60% corundum (by volume) and greatly diminished by 25%.

Clay No. 25 (containing 54.8% SiO_2 after calcination) expanded very rapidly between 100 and 200°. By using 60% corundum (by volume) this excessive expansion was materially reduced.

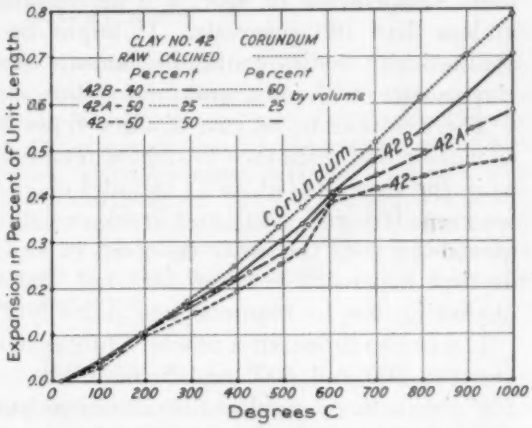

FIG. 11.—Curves showing the thermal expansion of clay No. 42, of mixtures of clay No. 42 and corundum, and of the corundum used in the mixtures.

Unfortunately the quenching tests were completed before these interesting results were obtained and consequently no data are available to show whether or not the mixture of clay and corundum having higher average, but regular expansions would be more resistant to sudden temperature changes than the clays alone.

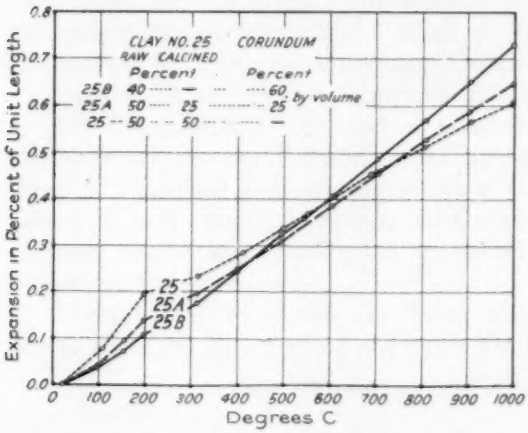

FIG. 12.—Curves showing the thermal expansion of clay No. 25 and of mixtures of clay No. 25 and corundum (the thermal expansion of the corundum used is shown in Fig. 11).

VII. Summary

This paper describes the results obtained with a relatively crude apparatus designed and constructed in the Ceramic Division of the Bureau of Standards for use in determining the thermal expansion of refractory clays and bodies, especially those used in the making of saggers.

The inversions of uncombined SiO_2 were sharply defined in some cases and barely discernible in others. A more thorough understanding

of the significance of thermal expansion, particularly in the range from room temperature to 300°, will necessitate expansion determinations at less than 100°-intervals. It might be advisable also to prepare synthetically bodies containing known quantities of practically pure clay matter, tridymite, and cristobalite, for expansion studies.

There appear to be two distinct types of clays as regards thermal expansion and resistance to sudden temperature change. One (referred to in the paper as Group L) includes clays which expand very rapidly between 100 and 200° and crack or "dunt" below 500° in the air-quenching test; the other (referred to as Group H) includes clays of average expansion between 100 and 200°, and which fail in the air-quenching test at temperatures above 500°.

It was also shown that repeated firings tend to decrease the expansion between 500 and 600° and increase the expansion between 100 and 200°, indicating a resultant decreased resistance to sudden temperature change.

Supplementary tests of clay-corundum mixtures clearly showed that artificial corundum, while increasing the total average expansion of the clays with which it was used, tends to eliminate irregular expansion due to inversions of uncombined SiO_2.

FUSION POINTS OF FIREBRICK–COAL-ASH MIXTURES[1]

By L. C. Hewitt

ABSTRACT

Six types of refractory brick were tested with five types of coal ash, the cone fusion points of the brick-ash mixtures being determined over a range of 10% brick, 90% ash, to 40 % brick, 60% ash. A departure was made from previous methods in that high ash mixtures were studied rather than high brick mixtures, in the belief that boiler slags contain a relatively low proportion of the refractory. Sintered mixtures of refractory and ash tend to give higher fusion points than the raw mixtures do. Any determinations made in an uncontrolled atmosphere are exceedingly unreliable. The results obtained in this investigation indicate that the "cone-slag test" is of very limited value as a means of selecting refractories for boiler service.

Introduction

The laboratory tests conducted in this particular instance were prompted by a desire to study the merits of the "cone-slag test" as means of rating certain types of fire brick in respect to their ability to resist the fluxing actions of various coals as met in boiler practice.

In this investigation a departure is made from the methods heretofore employed,[2] in that a high ash or slag content mixture was taken as the starting point, with a gradually increasing brick content. This departure is based on the belief that the glass, resulting from erosion of fire brick by coal ash in boiler furnaces, must contain a low percentage of brick. The amount of ash deposited on the walls daily is ordinarily quite high. If all of the slag formed by the action of the ash with the brick contained even as much as 25% brick, the walls would last a comparatively short time.

All of the ash does not come in contact with the brick, but, on the other hand, an examination of the surface of the brick exposed to slag in a furnace wall usually shows a very thin coating of slag, indicating that erosion is usually on the surface, rather than by penetration of the slag, leading to the belief that the amount of brick dissolved would be low.

The proportions of ash and brick that react with each other in common boiler practice are shown in Table I.

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[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (Refractories Division.)

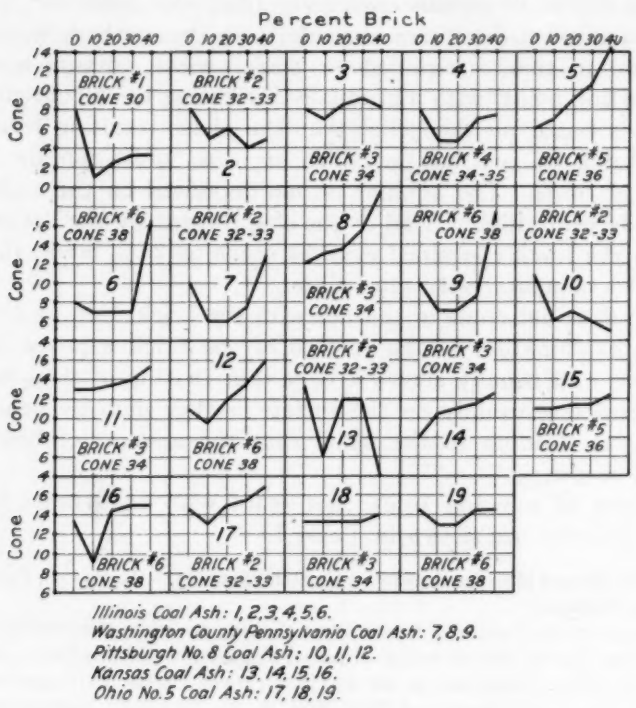
[2] Previous reference in the *Journal of the American Ceramic Society* to the procedure of conducting the cone-slag test and the results obtained with certain mixtures have been given by Howe, *Jour. Amer. Ceram. Soc.*, **6**, 466–73 (1923); Howe, Phelps, and Ferguson, *Ibid.*, **6**, 589–95 (1923), and by Booze and Flint, *Ibid.*, **7**, 594–98 (1924); Kohlmeyer, *Ibid.*, **8**, 313–18 (1925) makes mention of it. Brennan in *Combustion*, June, 1924, in a study of "The Effect of Coal Ash on Refractories" also gives data on the cone fusion points of various brick-coal ash-mixtures.

TABLE I

CALCULATED PERCENTAGE OF BRICK IN BOILER SLAG

Analysis	Slag taken from Brick No. 2 Sample A%	Slag taken from Brick No. 2 Sample B%	Ill. Coal Ash 100%	Brick No. 2 100%	Calcd. proportion of ash and brick in slag Sample A%	Calcd. proportion of ash and brick in slag Sample B%
Silica	49.46	52.00	49.44	57.52	100 ash 0.0 brick	70 ash 30 brick
Alumina	30.06	27.38	25.01	38.22	60 ash 40 brick	80 ash 20 brick
Iron Oxide	12.22	14.36	16.20	1.74	70 ash 30 brick	85 ash 15 brick
Titania	1.16	1.04	—	1.72	—	—
Lime	4.97	4.00	5.38	.31	90 ash 10 brick	75 ash 25 brick
Magnesia	.91	.92	—	.43	—	—
Alkalis	1.18	.95	—	.37	—	—

Slag Sample *A* represents a "stalactite" taken from the front wall of the boiler, and sample *B* represents a thin coating of slag of about $\frac{1}{16}$ inch in thickness, as taken from the sidewall brick. The data indicate that the glass resulting from erosion of fire brick by coal ash in boiler practice must contain a higher percentage of ash than brick; 40% brick content is the highest with the greater number under 25%.



Illinois Coal Ash: 1, 2, 3, 4, 5, 6.
Washington County Pennsylvania Coal Ash: 7, 8, 9.
Pittsburgh No. 8 Coal Ash: 10, 11, 12.
Kansas Coal Ash: 13, 14, 15, 16.
Ohio No. 5 Coal Ash: 17, 18, 19.

FIG. 1.

It has been thought there ofttimes is a tendency for some of the slag to

melt out from the mixture before the chemical action between the brick and ash of a test cone has been completed. The tests, shown in Table II, were made to determine the effect of sintering the brick-ash mixtures before determining the fusion point. The mixtures marked "reheated" were heated at 1200°C for three hours before being fused.

In six of the nine cases given, the fusion point of the reheated mixture is higher than that of the raw mixture, and in the other three cases, the fusion points are equal, indicating that in the cone-slag test, as usually conducted, the slag tends to act alone causing a premature softening of the cone. This, at least, seems to be the case for the range tested, and, no doubt, it would hold true to a certain extent in high brick mixtures. These data are shown graphically in chart No. 43, Fig. 4.

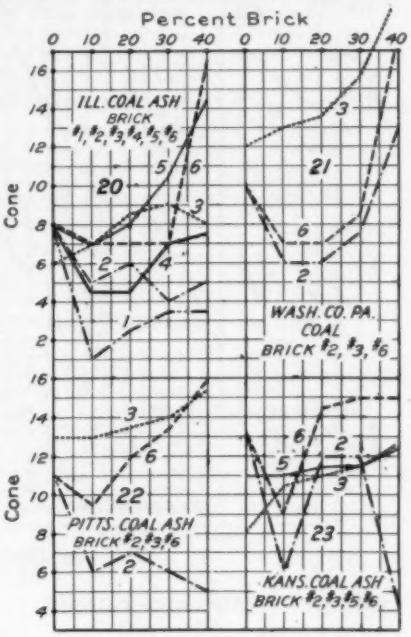


FIG. 2.

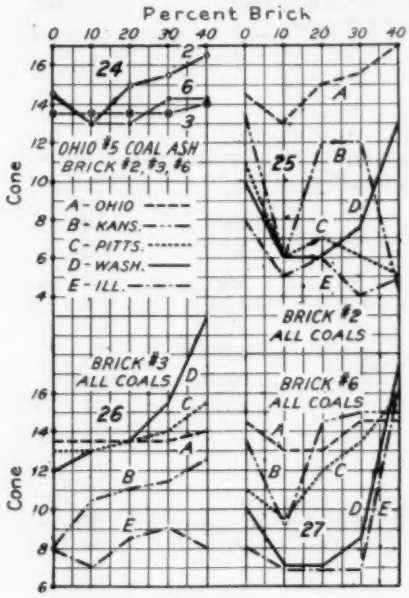


FIG. 3.

Brick-Ash Fusion Test Data

The Material Six brick, varying in in alumina content 32 to 75%, and five coal ashes, varying in iron content from 11 to 50%, were used. Samples of each brick were ground to pass 60-mesh. 50-pound samples of coal were secured from various mining sections. These were quartered to 5-pound lots, then to 3 pounds, the latter being fired in a clay crucible. The crucible was placed in a hot furnace at about 1000°C, and cooled down with free access of air. When coke formed, the sample was re-crushed and the oxidation process repeated. In all

cases the carbon was thoroughly burned without sintering the ash.

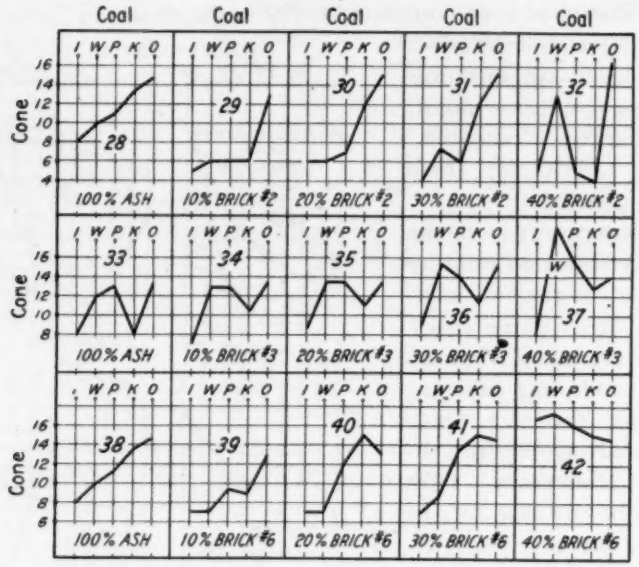


FIG. 4.

In the refractory-slag fusion tests made, bricks Nos. 2, 3, and 6 were the only brands tested with the ash of all coals included in this investigation, the two brands, Nos. 1 and 4, being used with the Illinois coal ash only, and brand No. 5 with the Illinois and Kansas.

TABLE II

Mixture	Fusion Point of Raw Mixture Temp. °C	Fusion Point of Raw Mixture Corresponding cone	Fusion Point of Reheated Mixture Temp. °C	Fusion Point of Reheated Mixture Corresponding cone
10–Kansas coal ash 90%	1330	10	1330	10
10–Pitts. No. 8 coal ash 90%	1250	6	1320	9–10
10–Wash. Co. Pa. coal ash 90%	1230	5	1280	7–8
10–Ill. coal ash 90%	1220	4–5	1260	6–7
20–Wash. Co. Pa. coal ash 80%	1250	6	1280	7–8
20–Ill. coal ash 80%	1220	4–5	1270	7
30–Pitts. No. 8, coal ash 70%	1300	8–9	1340	10–11
40–Kansas coal ash 60%	1350	11	1350	11
40–Pitts. No. 8 coal ash 60%	1370	12	1370	12

TABLE III

FUSION POINTS AND ANALYSES OF COAL ASH

	Illinois (inner group)	Wash. Co. Pa.	Pittsburgh No. 8	Kansas (Pitts. Dist.)	Ohio No. 5
Per Cent Ash	13.76	10.29	11.04	5.88	4.07
Fusion cone	6 and 8	10 and 12	11 and 13	8, 11 and 13–14	14–15
Silica	49.44	48.42	34.32	32.68	35.48
Alumina	25.01	29.51	12.22	20.82	28.08
Iron oxide	16.20	11.81	49.95	42.46	14.72
Titania	—	—	—	1.20	—
Calcium oxide	5.38	—	2.77	1.90	—
Magnesia	—	—	.34	.51	—
Alkali	—	—	.13	.91	—

Table III shows the per cent ash, fusion point, and chemical analysis of the ash as derived from the coals in question.

In Table IV is given the fusion point and chemical analysis of the

TABLE IV

FUSION POINTS AND ANALYSES OF FIREBRICK SAMPLES

	Brand No. 1	Brand No. 2	Brand No. 3	Brand No. 4	Brand No. 5	Brand No. 6
Fusion cone	30	32–33	34	34–35	36	38
Silica	63.44	57.52	49.60	42.04	29.84	17.58
Alumina	32.10	38.22	46.90	52.24	61.45	75.50
Iron	2.23	1.74	1.16	1.59	4.27	1.94
Titania	1.47	1.72	2.58	2.67	3.41	3.86
Lime	.32	.31	.15	.57	.32	.16
Magnesia	.06	.43	.34	.52	.13	.10
Alkali	.26	.37	.85	.77	.87	.55

Cone-Fusion Data on Mixtures

TABLE V

FUSION POINTS OF FIREBRICK-COAL-ASH MIXTURES

Brick No.	Illinois Coal Ash						Wash. Co. Pa. Coal Ash					
	100%	90%	80%	70%	60%	0%	100%	90%	80%	70%	60%	0%
1	8	1	2–3	3–4	3–4	30						
2	8	5	6	4	5	32–33	10	6	6	7–8	13	32–33
3	8	7	8–9	9	8	34	12	13	13–14	15–16	20	34
4	8	2–3	2–3	5	5–6	34–35						
5	6	7	9	10–11	14–15	36						
6	8	7	7	7	16–17	38	10	7	7	8–9	17–18	38

Brick No.	Pittsburgh No. 8 Coal Ash						Kansas Coal Ash					
	100%	90%	80%	70%	60%	0%	100%	90%	80%	70%	60%	0%
1												
2	11	6	7	6	5	32–33	13–14	6	12	12	4	32–33
3	13	13	13–14	14	15–16	34	8	10–11	11	11–12	12–13	34
4												
5							11	11	11–12	11–12	12–13	36
6	11	9–10	12	13–14	16	38	13–14	9	14–15	15	15	38

Brick No.	Ohio No. 5 Coal Ash					
	100%	90%	80%	70%	60%	0%
1						
2	14–15	13	15	15–16	17	32–33
3	13–14	13–14	13–14	13–14	14	34
4						
5						
6	14–15	13	13	14–15	14–15	38

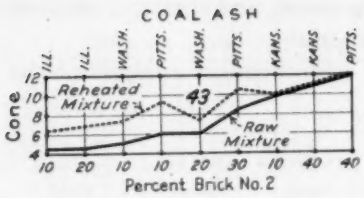


FIG. 4a]

six brands of brick tested, these being listed in order of increasing alumina content.

In Table V is listed the cone-fusion figures on the various mixtures of ash and brick.

On Charts 1 to 19 inclusive are curves for the fusion points of each brick when mixed with various percentages of ash of the various coals. Charts 20 to 24 inclusive give a composite view of the fusion tests for each coal ash when mixed with varying percentages of the brick; charts 25 to 27 inclusive show composite curves for brick Nos. 2, 3, and 6, as tested with the different coal ashes, and charts 28 to 42 inclusive show comparison between the coal-ash samples when fused with various percentages of brick Nos. 2, 3, and 6.

Fusion Data on Ash

Charts 20 to 24, and 28 and 33 show that the cone fusion of the same coal ash is not duplicated. Such a difference in the fusion of two samples of ash derived from the same 5-pound sample of coal, make it reasonable to expect a greater variation in tests on a coal ash at different periods, thus rendering the results of any one investigation of uncertain value in respect to any future application.

TABLE VI

EFFECT OF REDUCING CONDITIONS

Mixture		Fusion Points		
		Reducing Conditions		Oxidizing Conditions
Brick	Ash	°C	Cone*	Cone
%	% Kansas			
40	No. 3— 60	1191	3	12–13
30	"— 70	1170	2	11–12
20	"— 80	1191	3	11
10	"— 90	1191	3	10–11
	"—100	1191	3	8
40	No. 5— 60	1309	9	12–13
30	"— 70	1233	5	11–12
20	"— 80	1216	4–5	11–12
10	"— 90	1204	3–4	11
	"—100	1174	2	11
40	No. 5— 60	1417	14–15	14–15
30	"— 70	1290	8	10–11
20	"— 80	1306	9	9

* Calculated.

Effect of Atmospheric Conditions

Fusion determinations were made on various mixtures under reducing conditions, in order to learn whether some of the seeming discrepancies or differences might be brought about from this cause. The reducing conditions were obtained simply by using a large excess of gas in the pot furnace when the fusions were made. The results are shown in Table VI.

The effect of reducing conditions is so marked as to make exceedingly unreliable any determinations made in an uncontrolled atmosphere. In actual boiler practice, the atmospheric conditions do, of course, change; if the cone-slag test is to be analogous with practice it must compensate for furnace conditions and this it does not do.

Effect of Iron Content

From the standpoint of rate of reaction and ease of erosion, we would expect the high iron ashes (Pittsburgh No. 8 and Kansas) to give the most pronounced results. This is not found to be the case, as is shown in charts 25 to 27. Kohlmeyer[1] of the Detroit Edison Company states, "The slagging action of coal ash is due to the iron content of the coal. This conclusion was reached after using coals having both high and low percentages of iron."

Effect of Alumina Content

Howe, Phelps, and Ferguson[2] found with 4 to 50% slag that the refractoriness of coal ash slag-refractory brick mixes increased with the alumina content of the refractory, though not in direct proportion. This was not found to be the case in this investigation, where the percentage of slag in the mixture varied from 60 to 90%. This is shown clearly in charts Nos. 20 to 24 inclusive, the brick having been numbered in sequence according to the alumina content, No. 2 having a higher alumina content than No. 1, etc. In these charts the brick arrange themselves in the following order in respect to fusion point, when heated under presumably oxidizing conditions.

Per Cent brick	Illinois coal	Wash. Co. Pa. coal	Pitts. No. 8 coal	Kansas coal	Ohio No. 5 coal
10	1,4,2,3, 5,6	2,6,3	2,6,3	2,6,3,5	2,6,3
20	1,4,2,6,5, 3	2,6,3	2,6,3	3,5,2,6	6,3,2
30	1,2,4,6,3, 5	2,6,3	2,6,3	3,5,2,6	3,6,2
40	1,2,4,3, 5,6	2,6,3	2,3,6	2,3,5,6	3,6,2

[1] *Jour. Amer. Ceram. Soc.*, **8**, 317 (1925).

[2] *Loc. cit.*, p. 592.

General Observation

With the exception of the Washington County, Pennsylvania, coal-ash tests, the brick do not group themselves in any definite order. It is extremely difficult to draw any conclusions from the cone-slag test relative to comparative value of the refractories, for resisting coal-ash erosion. The fact that the fusion results may be altered entirely by a change in atmospheric conditions, and that eutectics form, and that reactions under various boiler conditions are not known, we are forced to conclude that the cone-slag test has very limited value in the selection of refractories to meet slag conditions in boilers.

With 50% and above of brick content, it would seem that the predominant factor in the fusion of brick-ash mixture, is the fusibility and alumina content of the brick itself (as found by Howe). This would apply strictly, however, only to fireclay refractories, other than those of very siliceous clays. It would be as logical to accept the comparative fusion points of the brick as it would be to accept the fusion points of high brick-ash mixtures.

Summary

The predominant ingredient of boiler wall slag is obviously coal ash rather than the refractory. The application of the cone-slag test to such mixtures develops that this test has very limited value as a means of rating the resisting qualities of refractories to coal-ash erosion in boilers,

(1) Fusion points on the ash from the same coal do not agree from time to time.

(2) Eutectics occur in fire brick–coal-ash mixtures. With no reliable data on the exact percentages of fire brick and coal ash that react with each other under actual boiler conditions, we have no standard guide of comparison.

(3) Any results secured in an uncontrolled atmosphere are exceedingly unreliable.

(4) The results secured do not coincide with practice inasmuch as the high iron ashes do not give the most pronounced results.

(5) The refractories do not group themselves in any defined order.

The author wishes to acknowledge the valuable suggestions made by M. C. Booze in this investigation.

LACLEDE-CHRISTY CLAY PRODUCTS CO.
ST. LOUIS, MO.

MACHINE PRESSING OF TERRA COTTA[1]

By Robert Galbraith

ABSTRACT

A brief history and a description of the operation of the compressed air pressing machine are given. The manual operations as well as the costs are itemized. The machine requires 15½ men for its efficient operation, while the cost of pressing and finishing one ton of terra cotta is $5.85.

One of the chief factors contributing to America's leadership in wealth has been the development of labor saving machinery in all branches of industry. These machines have made it possible to produce a far greater amount of goods per man. The terra cotta industry has been one of the laggards in developing machine operations but it is, in this respect, rapidly changing.

One of the most glaring wastes of labor in terra cotta manufacture has been the hand pressing. Production in this department depends entirely on a man's arms and shoulders beating the clay in the mold until the piece is formed.

In 1916, M. E. Gates began a series of experiments which resulted in a machine which operates on the principle of an automobile cylinder. A mixture of gasoline vapor and air is introduced under pressure into a chamber and exploded with an electric spark. This explosion presses the clay against the sides and the face of the mold. While this machine operates satisfactorily, Mr. Gates felt that it could be improved; so in 1923 he designed the compressed air machine here described.

We believe the machine has been perfected until it is nearly in the final stages of its development. It has been in continuous operation for over a year with very few shutdowns resulting from mechanical failures. During the last six months there have been no shutdowns of a day's duration, while in the last three months only twelve hours have been lost. The last month has not seen an hour lost.

Description of Gates Pressing Machine

A diagram of the machine is shown in Fig. 1. The steel tank contains 180 cubic feet of air at an approximate pressure of 120 lbs. per sq. inch. This air is supplied by a 7 x 6½, single stage, simplate valve air compressor driven by a 25-horse power motor.

A small hydraulic piston pushes a mold onto the palette *A*, which palette is then raised by another hydraulic piston into the chamber *B*. This chamber will accommodate molds of maximum dimensions of 28 x 40 x 26 inches.

As soon as the palette closes the chamber, the firing rod raises a small trip valve, *C*, which releases the air holding up the large trip valve, *D*. This allows the valve to drop which releases the air between

[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (Terra Cotta Division.)

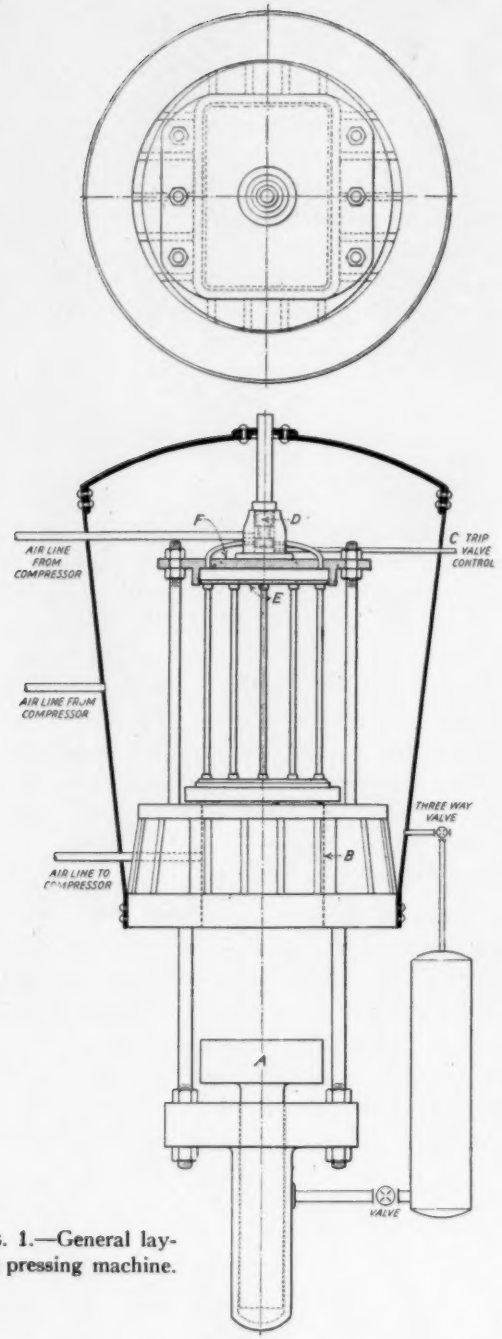


FIG. 1.—General layout pressing machine.

the two plates, *E* and *F*. When this air is gone, the unequal pressure raises the bottom plate which is directly connected to the valves below. When these valves are raised, the air in the tank rushes into the chamber with the speed of an explosion which presses the piece.

As soon as the mold is under pressure, the air compressor pumps the air out of the chamber back over the top plate forcing it down and seats the valves.

The chamber is then exhausted of its air upon which the piston valve releases and the machine is ready for the next mold.

The complete operation requires 36 seconds. With a larger compressor this time could be reduced. Figure 2 shows the mold on the palette ready for pressing.

Manual Labor Required A mold which has been blocked and dusted starts down the conveyor toward the machine. The first man cuts a piece of clay from his pile the size of the face and lays it in the mold. Then a man on

each side of the runway puts in the sides and ends sealing their junction by raking it with their fingers. Another man then puts in the partitions, or webbing, while two men seal the cracks between the different parts of the mold with soft clay.

The molds are propelled by means of a walking conveyor consisting of a series of arms attached to eccentrics turned by a worm gear. These eccentrics give the arms the alternate motion of raising and going forward, then lowering and returning.

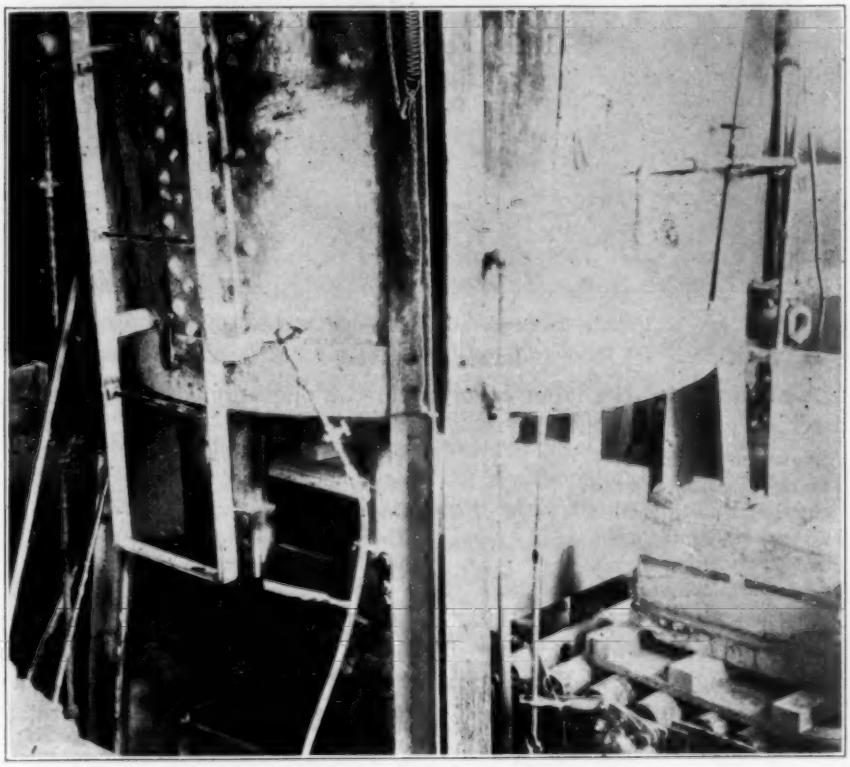


FIG. 2.—Mold on palette ready for pressing.

When a mold reaches the machine the piece is pressed, after which the excess clay is cut off the top and the inside of the piece is trimmed. High narrow molds are filled solid and the clay inside is dug out to form the partitions. Figure 3 shows same piece before and after pressing.

After rounding the curve, at the end of the machine, the mold goes on another conveyor which runs beneath a hot air pipe where, when it reaches the head end, the terra cotta is dried sufficiently to be dumped. Two men with the assistance of a small hydraulic piston dump the

mold and replace the sides, ends, and face in their proper places. The band is then replaced and the mold blocked and dusted by the checker.

The piece of terra cotta is placed in a steel rack which has a capacity of twenty pieces. This rack is then moved to the finishers with a lift truck. After finishing, the pressing operation is considered complete and the racks are trucked to the driers.

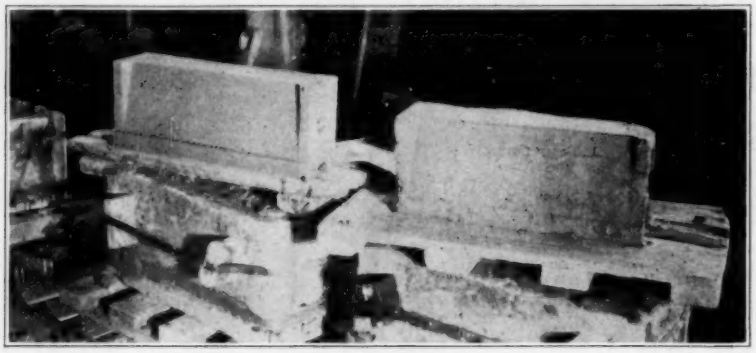


FIG. 3.—Same piece before and after pressing.

Labor Involved

A summary of the labor involved in the operation of the pressing machine gives the following:

One man putting in faces
Two men for sides and ends
One man for partitions
Two men sealing the mold
One man operating the machine
One man trimming the inside of the pieces
Two men dumping molds
One checker
One offbearer
Three finishers
One-half a trucker; one man trucks for two machines
One foreman in charge of both machines

This gives a total of 15½ men. The word "man" has been used here rather ambiguously as they are really boys of 17 and 18 years of age. They produce just as much terra cotta as men and are satisfied with a lower wage.

Cost of Operation

We have no figures of our own for a comparison of the cost of hand and machine pressing. Machine pieces range in size from 0.254 to 1.02 cubic feet. The average is 0.524 cubic feet while the average weight is 42 lbs.

Itemizing the cost of machine pressing gives the following:

Number of pieces pressed per man per day	33.33
Tons of terra cotta pressed per man per day	.729
Average daily wage per man	$4.10
Operation and maintenance per day	$5.00
Cost of machine pressing one ton of terra cotta	$5.85

AMERICAN TERRA COTTA AND CERAMIC CO.
TERRA COTTA, ILL.

SOME SOURCES OF AIR IN CLAY COLUMNS[1]

By S. L. Galpin

ABSTRACT

Absorbed gases are of considerable importance as sources of air in clay columns. A few measurements are reported, and inferences drawn thereon.

The air commonly present in green clay wares, and so often a trouble maker in clay columns is usually attributed to trapping of part of the air filling spaces between the fragments of crushed clay or shale used. While this source of air is no doubt responsible for much of that present in tempered clay, it seems probable that there is another source of some importance.

It is known that many substances, when finely divided, adsorb considerable quantities of gases. A simple experiment has been used to demonstrate that this property is also possessed by clays and shales to such an extent that its consideration as a source of air is worth while. When water is mixed with dry or partly dry clay it has the power to replace the air (or gas) films adsorbed or compressed upon the clay particles. The expansion of the air or gases released is proportional to the change of pressure resulting.

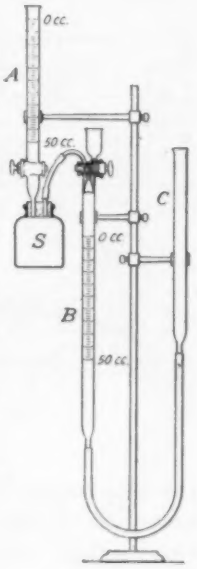


FIG. 1.

To measure this expansion of released gases, a weighed amount of clay is placed in a stoppered bottle (*S* Fig. 1). A measured amount of water is admitted from funnel, *A*. The change in volume of adsorbed air as it is released and expands, can then be seen and measured in a gas burette, *B*.

Results of some experiments with different clays are indicated on Fig. 2. The figures have been corrected for temperature changes, and the gas expansion calculated in per cent of clay volume.

With the exception of tests with one shale, the results are in general similar. Expansion of the air-water-clay system starts directly after water is added to clay. Probably none of the runs was carried to the point of complete air release as examination of the clay residues showed in each case a considerable number of hard, partly slaked lumps. The decrease in volume of the air-water-clay system, during the first few seconds of tests with Canton, Ohio, shale is possibly due to the compression of

[1] Presented by permission of the Director, Engineering Experiment Station, Iowa State College. Read at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (Heavy Clay Products Division.)

pore air by the water film advancing into the clay grains. The decrease stops when internal pressure disrupts the bonds holding the clay particles together.

The following statements concerning adsorbed air in clay seem warranted:

(1) Air-dried clay contains considerable amounts of adsorbed gases. (Whether clay adsorbs certain gases of the air in preference to others has not been determined.) These gases, when released from the compressing effect of adsorption may have a volume greater than that of the clay which contained them. A given clay will adsorb a greater percentage of permanent gases from dry than from humid air. Clay that has been wet for a long time probably contains no free air, although there may be air in solution.

(2) Adsorbed air may be driven from the surface of clay particles by water films. When just enough water is added to coat the clay particles the air may be largely adsorbed upon the water surfaces. When there is excess water in the clay the gases are released in proportion to reduction of adsorbing surface. The extent to which the released gases expand depends upon the confining pressure of the clay mass. With an excess of water some clays yield important amounts of adsorbed gases within three to five minutes after wetting. Others may require several hours to show appreciable change. In the making of some wares release may continue after shaping has been completed, with resulting swelling and loss of cohesion.

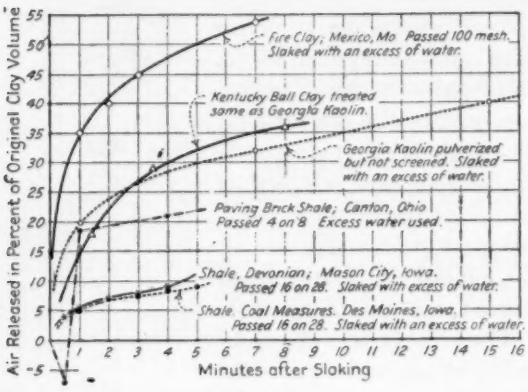

Air Released in Percent of Original Clay Volume
55
50
45
40
35
30
25
20
15
10
5
0
-5
Fire Clay; Mexico, Mo. Passed 100 mesh. Slaked with an excess of water.
Kentucky Ball Clay treated same as Georgia Kaolin.
Georgia Kaolin pulverized but not screened. Slaked with an excess of water.
Paving Brick Shale; Canton, Ohio Passed 4 on 8 Excess water used.
Shale, Devonian; Mason City, Iowa. Passed 16 on 28. Slaked with excess of water.
Shale, Coal Measures. Des Moines, Iowa. Passed 16 on 28. Slaked with an excess of water.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Minutes after Slaking

FIG. 2

Where only sufficient water is added to clay to yield stiff-mud consistency little adsorbed air escapes from the mass. Probably but part of the adsorbed air is released due to incomplete wetting. Such as is freed exists, if the clay is undisturbed, in minute bubbles.

(3) Agitation of clay with water hastens the release and expansion of adsorbed air by aiding penetration of water and by coalescing bubblets.

(4) Removal of adsorbed air from clay is difficult even when an excess of water is used. Blunging followed by aging seems most effec-

tive since blunging releases the larger bubbles and aging allows the removal of the minute ones through solution. Processes of tempering which cannot be expected to remove adsorbed air, should operate best when as little release and collection of bubbles as possible is caused.

(5) Alternate wetting and drying is an effective method for softening and fining clays and shales.

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PRACTICAL CHEMICAL CONTROL OF PICKLING ROOM SOLUTIONS[1]

By B. T. Sweely

ABSTRACT

This paper gives a brief outline of pickle room practice, and gives in detail a rapid method of titration of solutions by use of especially graduated cylinders and the addition of indicator to normal or fractionally normal solutions.

Chemical control of the strengths of the solutions used for cleaning, pickling, and neutralizing in the enamel industry, is essential if the best results are to be obtained. The methods and data submitted below are the results of several years' experience, and have proven practical and economical.

It might be well to observe at the outset that extreme accuracy is not attained by these methods, but since a variation of from 1 to .5% in acid solutions has but little effect on the pickling process, we have found these methods sufficiently accurate to control shop operations, and so simple and rapid that the pickle room foreman can test his solutions twice a day with no loss of time or production.

The pickle room practice at our plant is, briefly, to pack the ware in monel baskets and put it through the successive steps of cleaning, rinsing, pickling, rinsing, and neutralizing. After neutralizing, the basket of ware is set on a car and passed through a tunnel drier, after which it is ready for the dipping operation. No hand labor is used beyond loading the ware into the baskets and unloading it after it leaves the drier.

The control of the strength of the solutions used in the cleaning, pickling, and neutralizing operations, is a simple problem to the chemist, but our purpose was to so simplify it as to make it easy for the shop man to keep his solutions under definite control.

In testing the strength of the solutions, we have used normal or fractionally normal solutions of acid and alkali. For testing the cleaning solutions, a normal sulphuric acid solution is used; for testing the acid bath, a half-normal sodium hydrate solution is used; and for testing the neutralizing baths, we are using a tenth-normal sulphuric acid solution. These solutions, of the strength desired, may be purchased from any drug or chemical supply house, or, of course, can be made up as required.

Methyl orange is used as an indicator, as it gives a fairly sharp end point even in the presence of ferrous hydrate or CO_2 gas. This indicator is added to the standard solution when ready for use.

[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb. 1926. (Enamel Division.)

In determining the strength at which we wished to maintain the solutions, we neglected the actual weight of a cubic centimeter and assumed the per cent by weight of acid or alkali present was the grams per cc. shown by titration, *i.e.*, a normal NaOH solution containing .04008 gms. NaOH per cc. was considered a 4% solution. Obviously this method does not give per cent by weight of acid or alkali present, but the number of grams of acid or alkali present in each cc. of solution.

The strength of the baths we have found best suited to our solutions and working conditions are as follows:

	Per cent
Cleaning solution	3–5
Acid solution (sulphuric)	3½–5
No. 1 neutralizing bath	.6–.8
No. 2 neutralizing bath	.15–.20

Having determined the approximate strengths at which we wished to maintain the various baths, we modified the usual method of titration to meet the requirements for shop use, by putting the indicator in the standard solution and using a cylinder graduated to fit the job.

In testing for acid strength, we have graduated a cylinder at 10 cc. and in divisions of two cubic centimeters, up to 28 cc. The $\frac{N}{2}$ NaOH solution, colored by the methyl orange indicator, is placed in a half-gallon bottle, tightly stoppered with a siphon and pinch cock attached. The operator fills the graduate to the 10 cc. mark with acid from the pickling tank, and runs in the half-normal alkali until the color changes, then reads the grams of acid present in each cc., or per cent as above, direct from the divisions on the cylinder.

Since each division above the 10 cc. mark is 2 cc., and we are using a half-normal alkali to neutralize 10 cc. of unknown H_2SO_4 solution, it follows that each division above the 10 cc. mark represents approximately one-half gram of acid present in the 10 cc. sample. If therefore, the 10 cc. sample consumes less than 6 divisions (12 cc.) of alkali, the pickling solution is too weak and more acid is added to the bath; if more than 10 divisions (20 cc.) of alkali are required to change color, the pickling solution is too strong and water is added to dilute the bath to the proper strength. Continued use of this test develops the judgment of the operator to the point where it is really surprising how accurately he will estimate the amount of acid or water required, as the case may be, to bring the strength of the bath within the limits fixed for his guidance.

The same procedure is used in testing our cleaning and neutralizing solutions, but a different scale of graduations is used. These cylinders are graduated at 10 cc. and the following divisions are marked at

$2\frac{1}{2}$ cc. up to 10 divisions. The change in the scale is necessitated by the difference in molecular weight of the acid and alkali, that of sulphuric acid being approximately 50, while that of sodium hydrate is about 40. Since we wish to read in terms of 1% or 1 gram per cc., it is obvious the graduation must be in the necessary multiple of the molecular weight.

The standard solution used for testing and cleaning solution is a normal H_2SO_4 solution with methyl orange indicator added, and placed in a stoppered bottle as described above. The 10 cc. sample is placed in the graduate and the normal acid run in until there is a distinct color change as before; if less than three divisions ($7\frac{1}{2}$ cc.) are required to change color, the bath is too weak and more cleaning compound is added; if more than 5 divisions ($12\frac{1}{2}$ cc.) are required, the bath is too strong and must be diluted.

The neutralizing baths are tested in exactly the same manner, except that an $\frac{N}{10}$ acid is used in order to secure greater accuracy, and to permit the use of the same cylinder as is used for the cleaning solution test. That is, since limits of alkalinity are from .15 grams to .20 grams NaOH per cc. for the last tank, and from .6 grams to .8 grams per cc. for the first tank, we are working with concentrations only one-tenth as great as are those used in the cleaning operation, and consequently use a standard solution of only one-tenth the strength.

In testing these solutions therefore, a sample of 10 cc. from the last tank is placed in the cylinder, and the $\frac{N}{10}$ acid run in until the color changes. Should this require less than one division (2.5 cc.) the bath is too weak and more compound must be added; if more than two divisions are required (5 cc.) the bath is too strong and must be diluted.

Likewise for the first neutralizing tank a 10 cc. sample must consume at least 6 divisions (15 cc.) of the tenth-normal acid or the bath is too weak and if more than 8 divisions (20 cc.) is necessary to change color the bath is too strong and must be diluted,

The above sums up what we have found to be a rapid and practical method of keeping our solution strengths under control. As stated at the outset, great accuracy is not secured nor is it necessary, as changes of 1 to $1\frac{1}{2}$% in strength of the solutions will be encountered daily, due to exhaustion by the work handled, but it has enabled us to keep the baths within limits that we have found will give us satisfactory results.

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THE THEORY OF CLEANING OF SHEET IRON AND STEEL FOR ENAMELING PURPOSES[1]

By Homer F. Staley

ABSTRACT

Cleaning may be done by sand blasting, heating, use of solvents, or use of alkaline solutions. Of these methods, heating and use of alkaline solutions are important at present. In cleaning by heating the best results are obtained when the articles are first dipped in a solution of acid, heated uniformly to the lowest temperature that will cause the oils and greases to be burned off, and cooled slowly, both heating and cooling being done with the admission of as little air as possible.

In cleaning by the use of alkaline solutions, saponifiable oils are removed by the formation of soaps and the subsequent solution of these; non-saponifiable oils are removed by emulsification. Efficient cleaning depends primarily on the choice of cutting and drawing oils so as to have present a proper ratio of saponifiable and non-saponifiable oils. The cleaning solution must vary in composition according to the kinds and amounts of oils to be removed.

In the process of manufacturing black shapes for enameling from sheet iron and steel, they become more or less coated with greases and oils. These may be fats and greases used to prevent rusting while the stock is being shipped or is in storage, or oils used in cutting and drawing operations.

In order to avoid trouble in subsequent operations, it is essential that all traces of these oils and greases be removed before the shapes are subjected to "pickling." The process of removing these oils and greases is known in enameling technology as cleaning. The following methods are available: (*a*) sand blasting, (*b*) heating, (*c*) use of solvents, and (*d*) use of alkaline solutions.

Sand Blasting

The use of the sand blast is almost universal for cleaning cast iron for enameling. For fairly large pieces of simple shape it is quick and economical and has the advantage of removing not only oils and greases but also oxide of iron and scale. Therefore, it takes the place not only of the cleaning but of "pickling" operations. However, on account of the high air pressures employed in the commonly used type of sand blasting apparatus, the mechanical action is too severe for thin sheets causing too much abrasion and warping. The sand blast is used to advantage for cleaning steel shapes made from heavy plates for chemical apparatus.

There is no inherent reason why a sand blast apparatus operating at low pressures should not be devised for the cleaning of large thin pieces of sheet metal in simple shapes such as stove parts, signs, and

[1] Received June 18, 1926.

refrigerator linings. If, as is the case, it is possible to clean eggs by sand blasting it should be possible to clean thin steel shapes.

Cleaning by Heating

Cleaning by heating, commonly called "scaling," consists essentially of heating the ware to the temperature at which the oils and greases are volatilized or take fire and burn off. At the same time the outer layer of metal is converted to iron oxide and many of the strains set up in the metal during rolling, stamping, and spinning are relieved due to the annealing action in the furnace.

Since the formation of a heavy layer of oxide during the scaling operation is a decided detriment in the subsequent pickling operation, the process should be conducted in such a manner as to form the least amount of scale and to have this as loosely adherent as possible. The best results are obtained when the articles are first dipped in a solution of acid, are heated uniformly to the lowest temperature that will cause the oils and greases to be burned off and are cooled slowly, both heating and cooling being done with the admission of as little air as possible. The acid dip serves to partially loosen any heavy scale present and to cause the oxide formed during the heating operation to be fine grained and easily removable.

Use of Solvents

All oils, fats, and greases are readily removed by the use of solvents. The materials most available are benzol, kerosene, gasoline, and alcohol. Owing to the high cost of the solvents, the difficulty of recovering them and the fire hazards involved in their use, they are not used for cleaning enameling shapes. Occasionally a spot of grease or oil that has gotten onto a piece by accident is removed by swabbing it with a rag dipped in gasoline or kerosene.

Use of Alkaline Solutions

The commonly used chemical method for the removal of oils and greases consists in the use of alkalis in water solution or of substances which on dissolving in water give alkaline solutions. The alkaline salt need not be caustic soda or potash. Salts of weak acids which hydrolize and give alkalis may be used. Caustic soda, however, is the most effective, part for part, with trisodium phosphate, soda ash, sodium silicate, and borax following, arranged in the order of their efficiency.

In many cases the alkalis act as water softeners and hence hard water must be avoided because the alkalis are partly wasted and likewise form soaps or insoluble gummy materials which may be deposited on the ware.

Classes of Oils and Greases

With reference to their action with alkaline solutions, oils and greases may be divided into two groups.

1. Saponifiable oils and greases. These contain "fatty acids" which combine chemically with alkalis in solution to form soaps. They are of either animal or vegetable origin. They are also known as "fatty oils," which distinguishes them from both the mineral oils and the non-saponifiable animal and vegetable "essential" oils.

2. Non-saponifiable oils and greases. These contain no fatty acids and consist of mineral oils, essential animal oils, and essential vegetable oils.

A definite distinction must be made between the action of alkaline cleaners with saponifiable oils and their action with oils that are not saponifiable.

1. Saponifiable Oils When saponifiable oils, fats and greases occurring on the ware are brought into contact with alkaline solutions they first undergo emulsification and then saponification. That is, they finally form soaps.

Emulsification consists of the formation of a suspension of one liquid in another in the form of very minute drops. In this case, when the alkaline solution comes in contact with the oil or grease the first action is the dissemination of the oil in small drops throughout the liquid. This effect is purely one of surface tension.

Next there is a chemical action between the fatty acid in the saponifiable oil and the alkali in the solution which results in the formation of a soap. As most alkaline soaps are soluble in water, the soap dissolves leaving the surface of the metal clean. Heating the solution aids in the formation of the soap and in its subsequent solution.

Saponification of the fatty oils not only serves to remove these oils from the ware but also aids in the removal of other oils and dirt due to the action of the soap formed. Soap aids in the formation of emulsions of the non-saponifiable oils and also in the removal of particles of grit by taking them into suspension. The latter action is due to the circumstance that soap solutions have very low surface tensions. Therefore, when they envelop a particle of grit, the force with which the grit adheres to the surface of the ware is lessened, and the particle floats away or drops down into the bath. While the cleansing action of soaps is well known, it would be quite expensive to clean large quantities of ware by the use of regularly manufactured soaps. In this case, where there is present on the ware oils containing fatty acid, one of the two chief ingredients of soap, it is quite logical to add alkali, the other chief ingredient, and to actually manufacture soap in the cleaning bath. In cases where large amounts of grease and oil are to be removed and

there is little or no saponifiable matter present, both alkali and fatty acid (generally in the shape of rosin) may be added to the bath with advantage. A disadvantage in the formation of too much soap is that it is difficult to rinse it from the ware.

2. Non-Saponifiable Oils With non-saponifiable oils and greases, the first action of the alkaline solution is the same as in the case of the saponifiable oils. That is, an emulsion of oil in water is formed. Then the globules of oil gradually rise to the surface of the bath and coalescing, form a layer of oil on the surface.

This sounds very simple, but in actual practice it is very difficult to clean metals by emulsification of non-saponifiable oils by alkaline solutions alone. The emulsions do not form readily and are not stable; that is, they break down easily. Moreover, the globules of oil do not separate from the surface of the ware but adhere to it tenaciously.

The stability of the emulsion is dependent on the relative amounts of solution and oil, and on the amount of alkali in the water, or as it is at present fashionable to say, on the hydrogen-ion concentration. The greater the proportion of solution to oil and the stronger the solution is in alkalinity, the more stable the emulsion becomes. However, the greatest aid to the emulsification of non-saponifiable oils is the addition or production of a relatively small amount of soap. When any saponifiable oil is present, soap is produced automatically as explained above. Otherwise, soap or soap-forming ingredients may be added to the bath. Soap makes the emulsion more stable, preventing the breaking down of the emulsion as fast as it is formed and at the same time acts on the globules of oil in the same way that it acts on particles of grit, loosening them from the surface of the ware, thus permitting them to float to the surface of the bath. While a little soap is a great help, too much soap is a detriment since it makes the emulsion so stable that it will not break down at all so as to allow the oil to separate at the surface of the bath.

Another method of increasing the stability of emulsions is to add to the bath some solid so finely divided that the particles are colloidal in size. Their action is purely mechanical. Agitation of the bath either by passing into it steam or air or by stirring greatly aids the separation of the emulsified oil from the surface of the ware. Quite often inert materials of size larger than colloidal are added to produce a scrubbing or scouring action when the cleaning solution is circulated past the objects to be cleaned.

Electrolytic Cleaning

In addition to the regular alkaline solutions there is also employed electrolytic alkaline cleaning. This method is growing more and more

popular due to the decrease in the time required and the effectiveness of the cleaning. The concentration of the alkali solution used is usually about the same as in the method described above, about the only requirement being that the alkaline solution should be of high conductivity.

The articles to be cleaned are made the cathode and an iron anode is used or the iron cleaning tank is used as anode. The principle cleaning action results from the production of finely divided gases which lift off the oil or grease film and assist in its emulsification or saponification. This gas evolution likewise aids the stirring of the solution which continually brings fresh solution to the cathode surfaces.

Choice of Oils and Cleaners

From the foregoing discussion it is evident that there is no such thing as a "good cleaner for all sorts of work." For effective work the composition of the cleaner must be fitted not only to the amount of oils and greases present but particularly to the relative amounts of saponifiable and non-saponifiable oils.

Insofar as possible, drawing and cutting oils should be chosen with consideration to the ease of subsequent cleaning. If saponifiable oils are used exclusively, too much soap will be produced in the cleaning operation. On the other hand, if non-saponifiable oils are used alone, it will be difficult to emulsify them due to the absence of soap. The best combination of oils from the standpoint of subsequent cleaning is one which contains sufficient saponifiable oil to give the proper amount of soap to cause a fairly stable emulsion of the non-saponifiable oils.

If the combination of oils used gives too much soap, the obvious thing to do is to see that the cleaner contains no soap or ingredients containing fatty acids, such as rosin. If this is not effective the proportion of saponifiable oils should be reduced.

If the combination of oils used gives too little soap, recourse can be had to the use of some soap or rosin in the cleaner, but a more satisfactory plan would be to increase the proportion of saponifiable oils used.

By devoting a little study to the action of his cleaning solutions, particularly with the aid of a few test tubes and a low-power magnifying glass, the plant superintendent can determine whether his solution is too rich or too poor in soap, and change his oils or his solution accordingly.

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A SIMPLE "SEALED-IN MERCURY ELECTRODE" APPARATUS FOR TESTING THE BREAKDOWN VOLTAGE OF HEAVY INSULATING MATERIALS[1]

By Louis Navias

ABSTRACT

A method has been developed whereby thick plates of insulating materials (of small area) may be electrically punctured under oil. The specimen is cemented between two hollow electrode holders by means of red sealing wax, as illustrated. One electrode holder, the elbow, may be made of ordinary cast-iron piping or glass. Mercury poured into both tubes gives the necessary contact. It is possible by these means to puncture a porcelain cylinder of diameter $1\frac{1}{8}$ inches and $1\frac{1}{8}$ inches thick at 142 kv., and with a porcelain cylinder 2 inches in diameter and 2 inches thick to reach 176 kv. without arcing. The "sealed-in mercury electrode" method has been compared with two other methods employing spheres and disks as electrodes, by puncturing cast polished plate glass specimens. The new method gives consistent results, the values being on the average 15% higher than values obtained by the other two methods.

Dielectric Strength Test Specimens in Experimental Use

In plant control work it has been found expedient to use some manufactured shape, as an insulator, usually with the standard (metal) hardware attached and to determine the puncture voltage on the assembled article. The result is a composite one and serves to indicate the limits to be found in a simulative service test.

For purely experimental work a number of shapes of porcelain specimens have been advocated and used. A few of these are here indicated. Radcliffe[2] made shallow dishes by the jiggering process, $2\frac{7}{8}$ inches diameter across the top, 1 inch deep, with a bottom thickness of from 1.4 to 7 mm. The bottom was punctured in oil between two small-diameter electrodes. Weimer and Dun[3] made use of a cylindrical test cup $5\frac{1}{4}$ inches high, 3 inches diameter, and 0.15 inch thick. Electrical contact was made on both sides of the bottom with metal electrodes. It is here assumed that the walls and bottom were uniformly thick.

In their experiments on electrical resistivity Honeman and Fonseca[4] used a cylindrical cup 6.5 cm. high, 6 cm. diameter and a bottom 2.5 mm. thick. Their illustration shows a uniform thickness for wall and bottom with sharp corners between the two.

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[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb. 1926.

[2] B. S. Radcliffe, "Investigations on the Dielectric Strength of Some Porcelains," *Trans. Amer. Ceram. Soc.*, **14**, 575–91 (1912).

[3] George Weimer and C. T. Dun, "The Effect of Temperature on the Dielectric Strength of Porcelains," *Trans. Amer. Ceram. Soc.*, **14**, 280–91 (1912).

[4] R. K. Honeman and E. L. Fonseca, "Electrical Resistance of Various Insulating Materials at High Temperatures," Report 53, of the National Advisory Comm. for Aeronautics, pp. 15–23 (1920).

The American Society for Testing Materials in 1924 had two shapes for insulating materials. The "Standard Method for Testing Molded Insulating Materials," D 48–24, requires a cup $2\frac{1}{2}$ inches high, $2\frac{1}{4}$ inches overall diameter, with a central portion of the bottom about $1\frac{3}{8}$-inch diameter and 5 mm. thick. The inner wall is tapered from the bottom to the top, where the wall is only $\frac{1}{8}$ inch thick. Mercury is poured into the cup and the cup itself is floated on mercury to give the two electrodes.

Under the heading of the "Tentative Methods for Testing Electrical Porcelain," D 116–24 T, the American Society for Testing Materials requires a cylindrical tube, 12 inches long, of internal diameter $1\frac{1}{4}$ inches, and external diameter $2\frac{3}{4}$ inches, giving a $\frac{3}{4}$-inch wall. The center of the tube on the outside is grooved, radius $1\frac{1}{2}$ inches, giving a minimum section of porcelain $\frac{1}{2}$ inch thick through which the puncture occurs. Electrical contact is made on both sides of the minimum section by means of wet clay.

Felix Singer[1] refers to the fairly common use of plates with plane parallel faces held between disk or sphere electrodes and generally immersed in oil to prevent arc-over. He also mentions the factors by which the puncture voltage is influenced, some of these being thickness of specimen, the area of the electrode (the greater the diameter the lower the puncture value), the shape of the electrode, the effect of the duration of time to consummate the breakdown (usually the longer the duration the lower the value), the kind of current (direct or alternating), the frequency, and other factors.

The main object in the use of a large plate or a cup is to obtain the puncture through the direct path between the areas on the opposite sides of the same layer of insulating material, and in order to insure this happening the indirect paths between these areas are made long. There are no particular difficulties met with in the actual testing of such specimens. There is some difficulty, however, in the making of both of these types of specimens. For laboratory batches the quantity of material required for a single specimen is large. It is relatively difficult to make and fire uniform plane parallel plates of porcelain.

In the past two years cylindrical porcelain cups made by jiggering have been tested. The dimensions were 6 inches high, $2\frac{3}{4}$ inches outside diameter, 2 inches inside diameter, with a bottom $\frac{1}{4}$ inch thick, and a $\frac{3}{8}$-inch radius between inside wall and bottom, and no difficulties were encountered in the manufacture. The cup was floated on mercury, and mercury poured into the cup to give the

[1] Felix Singer, Die Keramik im Dienste von Industrie und Volkswirtschaft, p. 457 (1923).

two electrodes. Almost invariably the puncture occurred, not through the relatively thin bottom, but near the much thicker portion between wall and bottom, in spite of the inside curvature. Sometimes the puncture occurred in the wall above the curved portion, having a tortuous path. It was evident that in the jiggering process shearing of the mixture had taken place in the "corner" of the ware, which resulted in an electrically weak structure. Numerous changes were made in the method of procedure and in the dimensions of the test cup, but after a considerable period of experimenting there is no assured success. This situation led to the development of the method herein described, the criterion being the possibility of making a puncture on a simple thick specimen of porcelain, glass, or other insulating material.

Description of "Sealed-in Mercury Electrode" Apparatus

Of several modifications of the apparatus the type here depicted has been the most successful (Fig. 1). Essentially the apparatus consists of two hollow electrode supports, one a glass or metal elbow, the other a straight 6-inch length of glass tubing.[1] The elbow is held in a simple wooden frame. Originally the elbow was made of quartz glass but it has been found that pyrex glass is just as suitable and much less expensive. The metal elbow is made of three parts of ordinary plumbers' cast-iron stock, a length of pipe bent at an angle of 45°, an elbow and a short length whose upper surface has been machined flat. The glass parts have had their rims fire-flashed. Of the various common metals which could be used for the metal elbow it was found that cast-iron has a similar specific resistance to mercury, namely: mercury 94, cast-iron 98, while commercial iron is 9–12, soft steel 16, and hard steel 46.

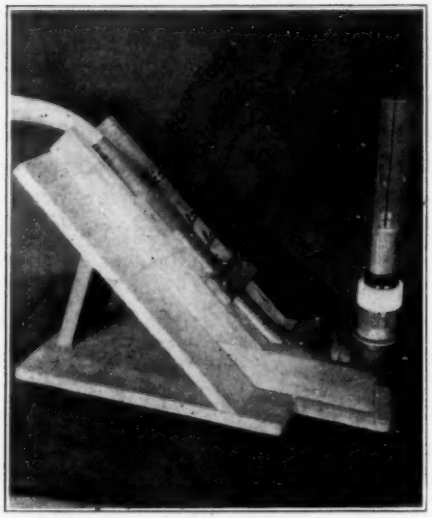

FIG. 1.

Sealing Specimen between Electrode Supports

The specimen to be tested is sealed between the two parts with ordinary red sealing wax. An efficaceous method is to invert the elbow, supporting the framework on a protruding board. A molten mass of

[1] The inclined tube is either glass or metal. Sealing wax is used underneath the specimen as well as above it.

wax is brought in contact with the rim of the tube, and by a succession of dips any thickness can be obtained. The specimen is then immediately brought in contact with the wax and after a short period of time the specimen will be held rigidly in place. The upper glass tube is then cemented to the specimen in a similar manner. Mercury is poured into the elbow, and the air entrapped is easily displaced by tipping the apparatus. In the glass elbow it is plainly seen how effective this simple process is in obtaining good contact between the specimen and the mercury. Mercury is also poured into the upright tube. Lead wires put in contact with the two mercury arms of the apparatus complete the circuit. In place of a long glass arm or a long pipe for the inclined electrode, it has been found feasible to use only a short rigid inclined portion with a rubber hose of large diameter attached.

Puncturing under Oil

For the actual test the whole apparatus is immersed in a bath of oil with the upper ends of the electrode supports protruding. The lead wires are thus maintained quite far apart. The voltage may now be applied and increased until the specimen is punctured, the path of the puncture being confined to the area inside the tubes. The metal elbow has a great advantage over those made of glass or silica glass, for after three or four puncture tests the glass elbows are found to crack below the specimen and near the right-angled bend. Whether this is due to the localized heating or mechanical shock has not been ascertained. The metal elbow after scores of punctures shows no signs of deterioration. The upright glass electrode support is not subject to the cracking.

Preliminary Tests to Determine Limits of Size and Puncture Voltage on Porcelain Specimens

A number of porcelain specimens of different sizes were punctured to determine the critical conditions and the critical dimensions. The specimens were of experimental batches intended for physical tests and are not of the same compositions. Some of the higher values are given in Table I as an indication of the range.

Of the different specimens punctured, the most crucial ones were those 1–1⅛ inches in diameter, having an area just large enough to cover the electrode holders. There is no doubt that the glass-sealing wax combination when immersed in oil is a sufficient barrier electrically to prevent arc-over. In air, the apparatus, namely, the metal elbow and glass cylinder with a porcelain specimen sealed between them, withstood 35 to 40 kv. before arc-over occurred around the specimen and through the wax. In this connection there would be great interest

TABLE I
PRELIMINARY TESTS ON PORCELAIN CYLINDERS

Sample No.	Elbow electrode	Specimen Diam. (in.)	Specimen Thickness (in.)	Kv. at breakdown	Volts per mil.
St.	Quartz glass	3	.490	60.8	124
195	" "	1⅛	.594	68.0	115
198	" "	1⅛	1.125	125.0	(tube broke)
St.	Pyrex glass	1	1.014	128.0	126.5
St.	" "	2	2.037	176.0	(no break) (capacity of transformer)
319 (2)	Cast-iron piping	1⅛	1.136	139.2	122.5
" (3)	" "	1⅛	1.103	142.4	128.8
" (4)	" "	1⅛	1.113	121.6	109.2
" (5)	" "	1⅛	1.120	140.8	125.5
St.	" "	3	0.50	64.8	130.0

in determining the most resistant cementing compound by direct comparisons of a large number of them. With a porcelain specimen, 1⅛ inches in diameter and 1⅛ inches high, immersed in oil, it is possible to withstand over 142 kv. With a specimen 2 inches in diameter and 2 inches high, over 176 kv. (the capacity of the transformer) were withstood without arc-over.

Comparison of "Sealed-in Mercury Electrode" Method with Sphere and Disk Electrode Methods of Determining Breakdown Voltage

In making this comparison there were two thoughts in mind, the first to determine the value of the "sealed-in mercury electrode" method as a reliable method, and the second to compare it with other standard methods. It was felt that porcelain consisting of a partially fused mixture was not sufficiently homogeneous, not only in composition but also in general structure, for this test. Cast polished plate glass has the advantage that it is made from a homogeneous fluid mass, and in the process of casting is laid down in a uniform layer, with the striae running in sheets parallel to the polished faces. Squares were cut from the same sheet of plate glass having uniform thickness, and were used in the tests, the punctures occurring between the polished faces.

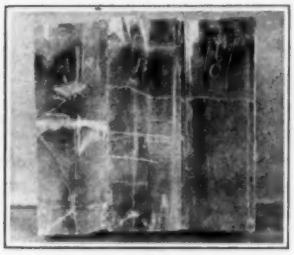

FIG. 2.

Electrodes

The *sealed-in mercury electrode* consisted of a metal elbow tube, ¾-inch inside diameter, with a corresponding glass tube. The disk

electrodes were also specially made for the test consisting of two brass cylinders, the upper one 2 inches high, 1 inch in diameter, one flat face having the corner rounded to $\frac{1}{8}$-inch radius, and the lower one similar in construction but only 1 inch high. The *sphere electrodes* were two brass spheres, of 1-inch diameter.

Dielectric Strength Test

After the specimen was placed in position between the electrodes the entire outfit was submerged in transformer oil. Alternating voltage of frequency 60 cycles per second was then applied at the rate of 1 kv. per second until puncture occurred.

The detailed results are given in Tables II, III, and IV, and a summary in Table V. Only one specimen, No. 1, was punctured by means of 2-inch disk electrodes, although a number were tried. Specimen No. 1 was a square 3 x 3 inches, 1.068 inches thick and punctured at 84.8 kv., yielding the low value of 79.5 volts per mil. The others arced over and for this reason they were punctured with 1-inch disk elecrodes.

Type of Puncture Path

Visually the path caused by the "sealed-in mercury electrode" method is materially different from the path caused by the disk or sphere electrodes. With disks and spheres the path is a line consisting of what appears to be a series of elongated bubbles in a capillary. In most cases the paths took the shortest distances between planes as in Fig. 2*C*, while in some the paths were curved as in Fig, 2*B*. From the path some small cracks branch off at various depths, but they are only visible when the specimens are viewed through the polished faces.

FIG. 3.

The specimens punctured by the mercury electrodes can be divided into two classes, those that have punctures similar to the above, and those that have punctures similar to Figs. 2*A* and 3. In these the path consists of a central fused thread from which branch numerous small cracks giving the effect of a spiral. At any depth the cracks branch out in three directions roughly 120° apart.

Discussion and Conclusions Based on Results

From the data obtained for plate glass it is evident that the new method of "sealed-in mercury electrodes" gives for a set of homogeneous samples consistent values in electrical puncture tests. The values are also comparable with those obtained by the standard methods using spheres and disks as electrodes, being however, uniformly higher

by about 15% for the same thickness of material. The average percentage deviation between values obtained by the "sealed-in mercury electrode" method is small but higher than the deviation calculated from values obtained by sphere electrodes, the disk electrodes giving a much higher deviation.

TABLE II

"SEALED-IN MERCURY ELECTRODES"—CAST POLISHED PLATE GLASS

Elbow of cast-iron piping ¾-inch inside diameter
Pyrex glass tube ¾-inch inside diameter

Specimen no.	Dimensions, inches		Breakdown kv.	Volts per mil.
	Area	Thickness		
2	3 x 3	1.054	121.6	115.3
3	"	1.053	110.4	105.0
4	"	1.064	114.4	107.5
23	1½ x 1½	1.060	129.6	122.3
27	"	1.067	117.6	110.3
31	"	1.067	110.4	103.7
32	"	1.066	108.8	102.4
Average (7)		1.062	116.1	109.5
% Average Deviation				5.0%
22	1½ x 1½	1.004	110.4	110.0
29	"	1.005	116.8	116.2
30	"	1.008	121.6	120.6
Average (3)		1.006	116.3	115.6
% Average Deviation				3.2%

TABLE III

ONE-INCH SPHERE ELECTRODES—CAST POLISHED PLATE GLASS

Specimen no.	Dimensions, inches		Breakdown kv.	Volts per mil.
	Area	Thickness		
6	3 x 3	1.063	102.4	96.4
11	"	1.053	97.6	92.6
12	"	1.067	100.0	93.8
13	"	1.066	107.2	100.5
14	"	1.063	100.8	94.8
15	"	1.056	96.0	90.8
17	"	1.063	96.0	90.3
18	"	1.057	94.4	89.3
19	"	1.068	100.8	94.4
20	"	1.057	99.2	93.9
Average (10)		1.061	99.4	93.7
% Average Deviation				2.5%

TABLE IV

ONE-INCH DISK ELECTRODES—CAST POLISHED PLATE GLASS

Specimen no.	Dimensions, inches Area	Thickness	Breakdown kv.	Volts per mil.
5	3 x 3	1.053	94.4	89.5
7	"	1.057	105.6	100.0
8	"	1.068	116.8	109.2
10	"	1.066	118.4	111.3
16	"	1.062	83.2	78.4
Average (5)		1.061	103.7	97.7
% Average Deviation				11.3%

Numbers 8 and 10 had to be insulated around the rough edges to prevent arc-over and allow puncture to occur.

TABLE V

SUMMARY—CAST POLISHED PLATE GLASS

Electrodes	No.	Av. thickness inches	Volts per mil.	Per cent average deviation
Sealed-in mercury	3	1.006	115.6	3.2
" " "	7	1.062	109.5	5.0
1" spheres	10	1.061	93.7	2.5
1" disks	5	1.061	97.7	11.3

The "sealed-in mercury electrode" method has the advantage that it requires a specimen of relatively small area (or a specimen with fairly short creepage path) to effect a puncture test, giving the opportunity of testing numerous samples and parts of samples of insulating materials not hitherto possible. A little more time is required, however, to make the complete test. There is another advantage in that the specimen required is simple in shape and obviates the complicated specimen which requires more time and care in its manufacture.

Better electrical contact is made between the mercury electrodes and the test specimen than between the metal electrodes and the specimen. With the sealed-in mercury electrodes the oil used in the bath does not intervene between electrode and specimen as is the case with sphere and disk electrodes.

The writer wishes to express his appreciation for the help given in this investigation by the staff of the General Engineering Laboratory.

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GENERAL ELECTRIC CO.
SCHENECTADY, N. Y.

SOME SUCCESSFUL CONE 10 SAGGER BODIES[1]

By E. H. Fritz

ABSTRACT

The various steps taken in the improvement of a cone 10 sagger body are described, which resulted in the development of several successful bodies giving a life as high as eighteen firings. Based on these results, a theory is advanced specifying limits for dry modulus, cone 10 absorption, and total shrinkage of the body, which if met regardless of clays used, will produce results such as were here obtained. Verification of this theory by others is requested.

About six years ago, when an enlargement of our plant was decided upon, we were confronted with the proposition of either enlarging our sagger-making department commensurate with the increase in plant capacity which was about to be made, or increase the life of our saggers to a similar degree, due to the fact that it required the capacity of the sagger-making department to furnish enough saggers for the eight kilns which we then had. The results obtained with our saggers at that time indicated that considerable improvement ought to be possible and we therefore decided to depend upon increased sagger life to take care of the plant enlargement. No exact determination was ever made, but as nearly as we can estimate it, our sagger life at that time was six firings. It is therefore not surprising that we felt that improvement could be made. The work which we have done since then has given results which surpassed all expectations. Some idea of them can be obtained from the fact that we have nineteen kilns today and our sagger-making department not only remains unchanged in size, but is making approximately 20% less saggers now than it did when there were eight kilns. How this was accomplished and the conclusions we arrived at in regard to successful sagger bodies at a cone 10 firing temperature, I believe is of interest to others.

Size of Grog

Work was done on the size of the grog and the outcome showed that the grog should not be finer than 12-mesh, of which approximately 75% should be between 3- and 12-mesh and the remaining 25% between 2- and 3-mesh.

Preparation

The preparation of the sagger body was studied, and it was decided to retain the well-known soaking method of getting it ready for the pug mill. However, the soaks were more carefully prepared; all lumps of clay were broken to a size not larger than a medium size ball mill

[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (White Wares Division.)

pebble, and alternating layers of clay and grog were not allowed to be thicker than three inches.

Thickness of the Sagger Bottoms

The saggers had been made with considerable variation in this respect, some of the bottoms being as thin as one-half inch. The weakness of such a sagger is apparent. This condition was remedied and the bottoms were not allowed to be thinner than 1 inch, and for the larger 17-inch diameter saggers and those which carry a heavy load, they were made 1¼ to 1½ inches thick.

Additional changes of a minor nature were made in the sagger-making operation, but those which I have enumerated are the important ones and serve to illustrate the general improvement which was made in the quality and uniformity of this operation.

Clay Selection

Some changes immediately suggested themselves by the dry and fired structure of the sagger body then in use. In the first place, the saggers were too weak when dry, causing considerable handling loss. After firing, the structure was very open and somewhat crumbly. It was therefore thought that a combination of clays, giving more dry strength and a tighter fired structure would give the desired results. Our sagger body, at that time, was as follows:

	Per cent
Tennessee ball, No. 1[1]	25
New Jersey clay, No. 1[1]	15
Pennsylvania colonial clay	10
Grog	50

We determined the dry modulus from test bars in pounds per square inch, absorption at cone 10, and total linear shrinkage on the wet basis for each of these clays and averaged each property for the body according to the percentage composition. In figuring the average modulus and shrinkage the grog was given a value of zero and averaged with the clays. For the absorption, the grog was, of course, disregarded. To illustrate this, I shall give the detailed figures for this combination.

BODY NO. 1, VALUES OF VARIOUS PROPERTIES

	Tenn. No. 1 25%	N. J. No. 1 15%	Pa. colonial 10%	Grog 50%	Av.
Modulus	100	300	0	0	70
Absorption	14%	12%	19%		14.4%
Shrinkage	20%	13%	9%	0	7.85%

[1] The numbers given with the clays have no significance and are used only to differentiate from clays used later from the same locality.

The modulus of the Pennsylvania colonial clay was too low to get an accurate reading. It is therefore given as zero, although in combination with other clays, it undoubtedly imparts some strength. The average then is the sum of the fractional parts of each property according to percentage composition of each clay. For the modulus this would be (.25 x 100) plus (.15 x 300) plus (.10 x 0) plus (.50 x 0) = 70. For absorption the properties cover the clays only as follows: (25/50 x 14) + (15/50 x 12) + (19/50 x 9) = 14.4%. In a similar way as for the modulus the average shrinkage was obtained.

Plasticity must of course also be considered, but since there is no satisfactory quantitative determination of this property, it is difficult to obtain any definite value. It is understood, however, that this body, as well as others tried, was sufficiently plastic to give a workable body for machine pressing saggers.

In order to increase the modulus and reduce the absorption, substitutions were made in the clays, and the grog reduced to 40%, resulting in the following body, the table giving the proportions, values of the properties, and the averages.

BODY NO. 2, VALUES OF VARIOUS PROPERTIES

	Tenn. ball No. 2 15%	N. J. No. 2 15%	Pa. ball No. 1 15%	Pa. colonial 15%	Grog 40%	Av.
Modulus	282	200	150	0	0	95
Absorption	7%	7%	0	19		8.25%
Shrinkage	13%	19%	20%	9%	0	9.15%

This body with its higher modulus eliminated the handling loss that had been encountered with the dry saggers. The fired structure showed the effects of the tighter firing clays, but there seemed to be a considerable amount of small cracks in it after the initial firing. This was ascribed to the higher shrinkage which was 9.15%, as compared to 7.85% for the previous body. This difference was not considered of much consequence and the new sagger mix was adopted and used for about one year. The results were very much improved, the sagger life determined by means of a sagger inventory at the beginning and end of a given period and considering the number of saggers made and the number of kilns fired during the period, being approximately eleven firings.

Further improvement, however, was thought possible to obtain. The modulus and absorption of this body appeared to be about right, but we were suspicious of the shrinkage due to the cracked structure which I previously described. It was desirable therefore to develop a body with approximately the same modulus and absorption as No. 2, but having a lower shrinkage. To accomplish this it was necessary to

find a fairly strong, tight firing clay having low shrinkage. A shaley type of clay, such as is found in Ohio, answered these requirements and it was substituted for the Pennsylvania ball No. 1, because this clay had the highest shrinkage and lowest modulus. The Ohio clay is a hard and strong material, but it responds readily to the action of water and develops fair plasticity. It was, however, ground in a dry pan before putting into the soak, to facilitate the action of the water. The resulting body and its properties are shown in the following table.

BODY NO. 3, VALUES OF VARIOUS PROPERTIES

	Tenn. ball No. 2 15%	N. J. No. 2. 15%	Ohio No. 1. 15%	Pa. colonial 15%	Grog 40%	Av.
Modulus	282	200	184	0	0	100
Absorption	7%	7%	3.25%	19%		9.09%
Shrinkage	13%	19%	10%	9%	0	7.65%

It will be noted that the average shrinkage for this body is lower than either of the previous two, and the absorption, while slightly higher than No. 2, is still considerably below No. 1. The fired structure seemed improved by this change with considerably less cracks, and had sufficient tightness to appear strong.

In order to determine the life of the saggers more definitely, a lot of one hundred was made up in one of our standard sizes, and assigned to one kiln, to be used for each firing. They were used in the bungs between the bags in every firing. This gave uniform conditions, and at the same time subjected them to what we believe to be the most severe condition which we have. It is here that the heat and flame action is most intense. While the load is not quite as great as in the center of the kiln where the bungs are higher, we believe that the more severe heat conditions over-balance the load difference.

The size of the sagger used for this and later bodies was 12 inches inside diameter and $5\frac{1}{4}$ inches inside depth. The thickness of the bottom was $1\frac{1}{8}$ inches and the side walls $\frac{3}{4}$ inch. No record was made when a sagger became unfit for further use, but instead it was decided what the life of the sagger body would be when one-half had failed. After 15 firings, 52 saggers remained and this was therefore considered the life.

The results with this body when adopted for regular use agreed with the test result. The saggers were by far the best we had ever had and their longer life more than took care of the additional kilns which by that time had been built.

No further work of any importance was done until about a year ago when the receipt of a considerable number of new sagger clay samples suggested trials of entirely different sagger bodies, but having similar average values for modulus, absorption, and shrinkage, in order to

determine whether such values might be taken as a basis for a successful cone 10 sagger body. Each trial was made in exactly the same way for the previous body in order to obtain true comparisons. The several bodies tried and results obtained follow.

BODY NO. 4, VALUES OF VARIOUS PROPERTIES

	Ohio No. 2 38%	Penn. No. 2 17%	Grog 45%	Av.
Modulus	190	0	0	72
Absorption	5.04%	14.7%		8.0%
Shrinkage	11%	15%	0	6.71%

The Pennsylvania No. 2 clay used in this body is very similar to Pennsylvania colonial clay, except that it is lower in free silica and has higher shrinkage.

The Ohio No. 2 clay is somewhat similar to the Ohio No. 1 used in body No. 3, except that it is considerably more weathered and as a result has greater plasticity. Its modulus is hardly any higher but I believe it exerts more strength than is indicated by the value given. The average modulus as a result is practically as low as body No. 1 but actually was somewhat better. However, the body is barely strong enough for commercial work and the grog should be 3 to 5% lower to improve this.

It will be noted that the average absorption is 8%, which is the lowest which had been tried up to this time. This resulted in a rather tight sagger and brittleness was expected. However, the sagger life proved to be eighteen firings, which was the best so far obtained.

BODY NO. 5, VALUES OF VARIOUS PROPERTIES

	Maryland No. 1 10%	N.J. No. 3 15%	N.J. No. 4 25%	Grog 50%	Av.
Modulus	180	265	81	0	81
Absorption	0.27%	12.4%	15.2%		11.37%
Shrinkage	16%	11%	11%	0	6.0%

This body does away with the shaley type of clay, the Maryland and New Jersey No. 3 being of the ball type, while the New Jersey No. 4 resembles a china clay and is another entirely different clay combination.

The average modulus again is lower than No. 3, due largely to the high proportion of grog, but actually the mix appeared sufficiently strong. Its average absorption is considerably higher which was noticeable in the sagger structure. The life determination resulted in eighteen firings or equal to No. 4.

BODY NO. 6, VALUES OF VARIOUS PROPERTIES

	Tenn. Ball No. 2. 6%	N.J. No. 2 16%	Ohio No. 1 16%	Pa. colonial 16%	Porcelain body 6%	Grog 40%	Av.
Modulus	282	200	184	0	350	0	99
Absorption	7%	7%	3.25%	19%	0		8.51%
Shrinkage	13%	19%	10%	9%	13.5%	0	7.67%

This body is a different combination of the clays used in body No. 3 and in addition a small amount of porcelain body which cannot be used again in the regular process. It represents an effort to use this porcelain body material but maintains practically the same average values as No. 3. It gave a life of fifteen firings, the same as obtained with No. 3.

BODY NO. 7, VALUES OF VARIOUS PROPERTIES

	N.J. No. 5 29%	Ohio No. 1 14%	Pa. colonial 14%	Grog 43%	Av.
Modulus	292	184	0	0	111
Absorption	12.2%	3.25%	19%		11.75%
Shrinkage	12%	10%	9%	0	6.18%

Here we have a partial substitution of the clays used in No. 3 through the use of another New Jersey clay. It gave high dry strength and low shrinkage, but the absorption was the highest tried. The life of this sagger was found to be sixteen firings.

Summary of Data

To facilitate comparisons of the various bodies tried, the following table gives the average modulus, absorption, and shrinkage of each body, together with the sagger life in number of firings.

	Body No. 1	Body No. 2	Body No. 3	Body No. 4	Body No. 5	Body No. 6	Body No. 7
Modulus	70	95	100	72	81	99	111
Absorption	14.4%	8.25%	9.09%	8.0%	11.37%	8.51%	11.75%
Shrinkage	7.85%	9.15%	7.65%	6.71%	6.0%	7.67%	6.18%
Life	6	11	15	18	18	15	16

Considering the bodies which gave the best results, Nos. 4 and 5, it is noted that the absorption varies from 8.0 to 11.37% and the shrinkage from 6.0 to 6.71%. It will be quickly seen that none of the remaining bodies come within these limits for both properties. In No. 1 the absorption and shrinkage are higher, the absorption considerably so, and the life is only one-third as long. In No. 2, the absorption is within the limits, but the shrinkage is higher and the life is approximately 60% as long. In No. 3 the absorption is again satisfactory, but while the shrinkage is less than No. 2, it is still slightly higher than the upper limit, and the life is 83% of Nos. 4 and 5. Number

6 classifies the same as No. 3 and the life remains the same. Number 7 shows satisfactory shrinkage, but slightly higher absorption, and the life is slightly lower.

Conclusion

No bodies were tried having lower absorption and shrinkage than the limits of Nos. 4 and 5. As far as absorption is concerned, I believe that lower than 8% would be detrimental, because 8% absorbtion gives a very tight sagger, and lower than that would introduce brittleness and heat strains and lower the heat conductivity. It appears reasonable, however, that a lower shrinkage may improve the results, and this suggests the use of larger proportions of grog and an organic binder to maintain sufficient modulus. The modulus of the bodies tried was satisfactory when above eighty and this value is therefore considered a minimum for satisfactory dry strength. The idea of lower average shrinkage from the use of more grog as well as from new combinations of clays will be tried in the near future.

On the basis of results obtained so far, I would like to advance the theory that a successful cone 10 sagger body must have a dry modulus of not less than 80 pounds per square inch, an absorption at cone 10 of not less than 8%, nor more than 11½%, and a shrinkage of not more than 7%, regardless of what clays are used, assuming that sufficient plasticity is provided, the grog sized to the best advantage, and the body carefully prepared.

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TANK BLOCK CORROSION BY SHELVING[1]

By F. C. Flint and A. R. Payne

ABSTRACT

Photographs are given showing a number of glass tanks which indicate that part of the rapid eating of tank block is due to upward solution from cracks in the block wall. This upward solution is due to the higher specific gravity of the glass after dissolving tank block material. Experiments made by adding clay to glass melted in small pots and analyzing show this. The density is also taken of glass adjacent to the tank wall.

The method of corrosion of tank block has been the subject of a good deal of study and observation. Very often an individual investigator will come to a certain conclusion and stress it so strongly that the implication is left that it is the only method by which the block dissolves. Actually, there are probably a number of factors involved in the solution of the tank block in the glass, no one of which greatly predominates over the others.

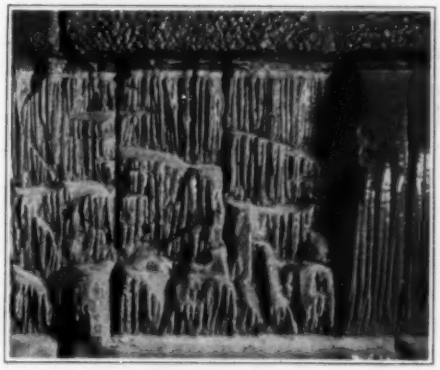

Fig. 1.

The ideas given below and the photographs to support them are given entirely with the thought that this cause of corrosion is only one of many in any given tank of average bottle glass and contributes only its share.

Enough tanks have been examined to indicate that a very large percentage of them corroded, at least partially, in the manner described. This manner of corrosion is by the formation of fine cracks on the inside surface extending gradually into the block, often not reaching the outside surface, the block going into solution at the line where the crack starts, at the inside wall. The block goes into solution quite rapidly along this narrow zone and solution is predominantly upward from the crack, leaving a shelf at the bottom. This is shown by the photographs in which most of the corrosion indicated is upward.

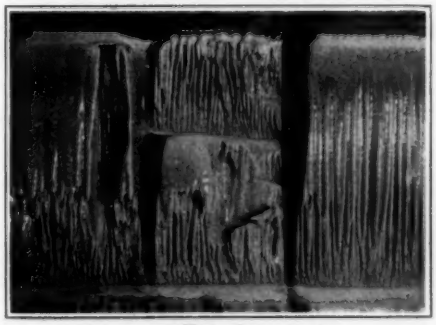

Fig. 2.

[1] Received July 8, 1926.

Figure 1 shows two 12 x 24 x 30 blocks badly shelved, with a good block to the right. The good block was eaten out from the bottom along the horizontal crack between the courses, but after four and one-half months was not bad, being about ten inches thick near the top. The other blocks are badly shelved, and above each shelf the blocks are eroded very much as the walls of a natural canyon give way by steps. These blocks are only a few inches thick near the top. Corrosion at the bottom seems to have been normal and would have proceeded as on the good blocks, had not the shelving hastened matters by working from beneath at a great number of places.

Figure 2 shows another comparison between cracked and sound block. As usual the sound block are nearly full thickness near the top, but in the cracked block a horizontal shelf cleaned out the top half of the poorest block and the other cracks are gradually eating up from below. The block to the extreme left is cracked vertically. This does not seem to be as bad as a horizontal crack; it does not go so deep.

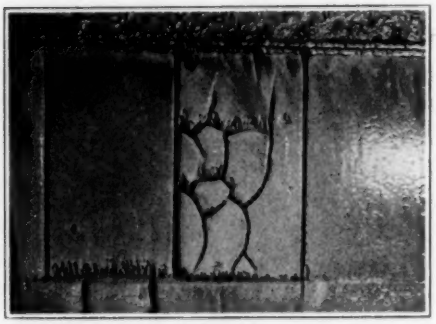

FIG. 3.

Figure 3 is taken from the refining chamber just over the flow hole in the bridge. The top course flux block directly over the flow shows where the hot glass has come up from underneath and corroded the bottom of the block at "A." The bottom course shows deeper cutting. The block to the right being a little distant from the flow is not subjected to the hot glass and is in very much better condition at "B." This is a very good example of the effect of increased temperature on the rate of corrosion of the tank block.

The block which is subject to the most wear at the bottom being directly over the flow hole, was in good shape and not cracked and showed little evidence of being attacked by the glass, except at the bottom where the horizontal shelf at the joint started corrosion. The block next to it, however, though not under quite such severe temperature conditions, was very much worse off.

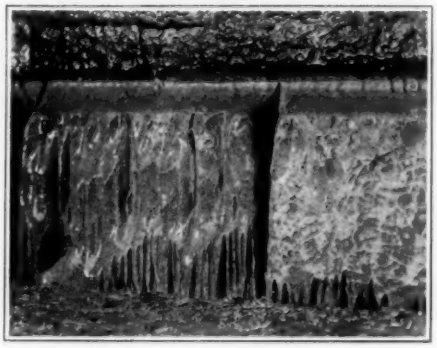

FIG. 4.

The cracks, looking very much like mud cracks, had sunk in an inch deep where they were off the horizontal and several inches deep where they were horizontal. Also, when horizontal, corrosion had immediately started upward with the customary formation of stalactites and folds. The reason this is not as far advanced as the one previously shown is because the lower temperature has prevented this from going so far in the time used.

Figures 4 and 5 are shown to indicate the effect of shelving and cracks on supposedly similar block of different thickness in a small furnace. Figure 4 is a 12-inch block in a small tank. The one to the left is very slightly shelved, but the crack apparently did not go in very far. The one to the right was in exceptionally good shape so far as cracks were concerned, with the result that very little corrosion occurred. These block started 12 inches thick and were approximately 8 inches thick at the end of the fire.

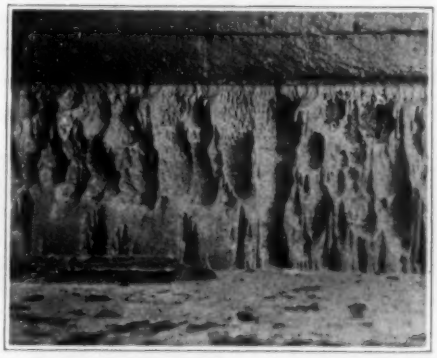

FIG. 5.

In Fig. 5 on the opposite wall of the same furnace, block 8 inches thick were put in to try out the value of an 8-inch block. The experiment was indicative of nothing so far as a comparison between the two thicknesses was concerned because these block were very badly cracked, with the result that they corroded, due to cracks becoming in some places so thin that the water box put on to patch with, could be seen through. It may possibly be that an 8-inch block cracks easier than a 12-inch one, though such is not generally conceded to be the case. It rather looks as if something about the manufacture in these 8-inch block was different from that in the 12-inch which caused them to crack, or it may be that 8-inch block are more susceptible to wind cooling on the outside than 12-inch block, and this caused them to crack.

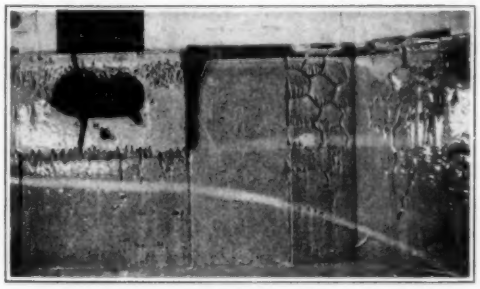

FIG. 6.

Figure 6 is taken from the right front corner of the working end of a large tank. The block in the center is exceptionally good, that next to it badly cracked. Approximately one-third of the block

in the refining chamber of this tank were in good shape; the rest of them showed signs of cracking. Here the temperature being only about 2350°F the glass attack was not so rapid as in the melting chamber with a temperature of 2600°F or above.

The upward eating at the crack is again evident. This is also noticed in the skimmer block to the left, the bottom of the skimmer hole being very little touched, the top being eaten three or four inches. These block were made the full 42-inch depth of the tank and so were supposed to get rid of the horizontal joint between the first and second courses. This is true of the good block which introduces no joints of its own, but the majority of the block in the tank contributed far more horizontal joints than would be made in laying up the tank. Most of the block showed evidence of more corrosion near the top of the block than the bottom, though the cracks seem distributed all over. This can be seen in the long block to the right of the good one. The corrosion is due to the effect of temperature on the glass and block. The cracks do not seem to depend on this. The majority of the block examined indicated that they are eaten away from below upward, not from the top down. It is quite common to picture the block as eating out as indicated in diagram A, whereas diagram B (Fig. 8) has been found more often to be descriptive, lines 1, 2, 3, and 4 indicating successive stages in the corrosion of a good block.

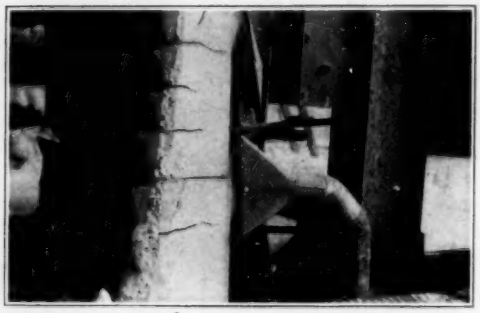

FIG. 7.

These cracks look very much like mud cracks. They may have been started in drying or firing, or in heating up the tank. If in heating up the tank some block seemed able to withstand the temperature change better than others. However, the refining chamber should be heated more uniformly than the melting chamber and in this particular tank nearly three weeks were given to the schedule.

Figure 7 shows the cracks which apparently are causing the shelving. This picture is taken from the inside wall at the rear of the tank at the corner of the dog house. The shelves are shown with the corrosion upward, the shelf extending out nearly to the original inner face of the block except where the shelf below is eaten up to it. The very fine hair-line cracks indicated are so small that they had to be penciled in order to be photographed. They were so small that they were barely able to be seen and a thin paper could not be inserted in them. None of them

extended to the outside wall of the block; most of them are horizontal, a few vertical ones being shown and one which seemed to start and stop on the interior of the block. Breaking the block would not show this because the block would break along these small hair-like cracks.

The size of the crack does not seem to have a great deal to do with the size of the shelf as can be seen by the horizontal joint between the bottom and top courses. Glass penetration into the crack seems to have been not more than $\frac{1}{64}$ inch at the corner where the shelf stopped and the crack began. This small area was sufficient to extend the corrosion back in the block far more rapidly than the corrosion could attack a smooth face.

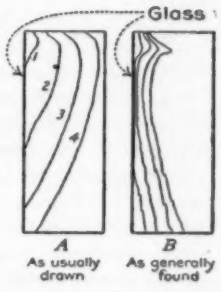

FIG. 8.—Outline sketch of progress of tank block corrosion.

This penetration upward may be explained by the increased density of the resulting glass after solution of the clay material. The shelf holds the more saturated, more viscous glass longer, so does not eat away as rapidly, whereas the roof of the crack is quickly exposed to fresh glass, which is farther from equilibrium with the solid phase. This layer of saturated glass in one series of tests was found to be not over $\frac{1}{32}$ inch thick and gave densities as follows:

Glass in tank	2.450
Glass near block	2.50 to 2.55
Density of block	2.639

Later this was checked up by melting some glass of a given density and analysis with clay.

GLASS COMPOSITION

		%
Sample of tank glass	SiO_2	74.23
	Al_2O_3, Fe_2O_3	.55
	CaO	4.78
	MgO	3.32
	Alk. (diff.)	17.12
Density		2.4602

		I	II	III
Sample after remelting and introducing clay	SiO_2	71.51	71.62 %	69.74 %
	Al_2O_3, Fe_2O_3	6.74	5.61	6.18
	CaO	4.98	5.91	6.78
	MgO	3.29	3.11	3.32
	Alk (diff.)	13.48	14.35	14.98
Density		2.515	2.493	2.517

HAZEL-ATLAS GLASS CO.
WASHINGTON, PA.

TEMPERATURE OF PYREX AND PORCELAIN IN SUNLIGHT[1]

By J. T. Littleton, Jr. and W. W. Shaver

ABSTRACT

The relative temperatures of Pyrex glass insulators and porcelain insulators in sunlight are determined in three ways. A computation using the radiation and convection heating equations gives a value of 93°C as a maximum surface temperature of porcelain in sunlight, with an assumed shade temperature of 40°C. In a similar way 46.5°C was determined for the Pyrex insulator. Measurements are given of the rise in temperature under natural conditions of Pyrex and porcelain insulators mounted on pins. Temperature measurements were made by means of thermocouples cemented to the surface of the insulators. Extreme conditions were further obtained by means of tin reflectors. Under such conditions the experiments show that the temperature of the porcelain insulator increases on the average about three and one-half times that of the Pyrex glass insulator.

Introduction

The question of the temperature a body may attain when exposed to extreme sun heat such as in the tropics or in the clear air of mountain peaks does not seem to be very definitely established. There are measurements of soil temperatures and measurements of the solar radiation constant but direct observations of maximum temperatures of black bodies in a quiet atmosphere, but subject to free convection, seem to be lacking. Yet these temperatures are of importance when it comes to drawing up specifications for materials subjected to natural temperature changes. Specifications for tests should at least equal the conditions met with in service.

Langley[2] has observed a "hot box" temperature of 113°C. This was obtained by means of a thermometer in a glass-covered box having insulated sides. This would unquestionably be a somewhat higher temperature than would be attained by the surface of a black body of a fairly non-conducting material for the heat loss from the glass cover would be somewhat less than that of the black body since the glass is undoubtedly at a temperature lower than that of the thermometer.

In electrical insulator tests a "hot and cold" test is often specified which demands sudden chilling from boiling water. While it is not claimed that insulators are ever as hot as 100°C in service due to the solar heat it was believed to be worth while attempting to determine just what the maximum temperature of a porcelain insulator might be and also to compare this temperature to that attained by a non-absorbing material such as Pyrex under the same conditions.

[1] Received June 7, 1926.

[2] Researches on Solar Heat, p. 166, 1884.

Theoretical Computation of Maximum Temperature

The temperature attained by a body can be computed from the known thermal laws. Take first the case of a black disk having very little reflectivity placed horizontally with a corrugated under surface so that convection losses from this surface are negligible. Suppose this disk to be 25 cm. in diameter and 2.5 cm. thick on the average, then let:

T_1 = temperature of upper surface of disk in °A
T_2 = temperature of lower surface of disk in °A
T_3 = temperature of earth and atmosphere in °A
α = conduction of material 2.5 cm. thick per sq. cm. per °C
C = radiation constant for total radiation per sq. cm. in Stefan's equation
K = convection constant for upper surface
E = energy per sq. cm. falling on black body from the sun per sec.

Then neglecting the loss of heat by radiation and convection from the edges we have the following equations:

$$\alpha(T_1 - T_2) = C(T_2^4 T_3^4) \qquad (a)$$

$$E = C(T_1^4 - T_3^4) + K(T_1 - T_3)^{5/4} + \alpha(T_1 - T_2) \qquad (b)$$

Where $K(T_1 - T_3)^{5/4}$ = heat loss by convection from the upper surface per sq. cm. per sec. as found by Montsinger and Cooney.[1]

The solution of these equations is best obtained by trial.

The value of K is 0.00027 and is obtained from Rice's formula.[2]

E is the solar radiation constant and is 0.124 watts per sq. cm.[3]

Assume an air temperature and earth temperature that is T_3 of 40°C.

Determination of T_1 and T_2

Suppose the black disk to be porcelain, then

Specific conductivity for porcelain = .0025 gm. cals. per sec. per sq. cm. per 1°C fall in temp. across 1 cm. thickness

or α = .00411 watts per sq. cm. per 1°C fall in temp. across 2.5 cm. thickness

$c = 5.72 \times 10^{-12}$ (to give results in watts per sq. cm.)

E = 0.124 watts per sq. cm.

Assume T_3 = 40°C or 313°A

The solution of these equations gives a

T_1 = 93°C

T_2 = 84.3°C

This means that the upper surface of a porcelain insulator might actually be as hot as 93°C in a quiet atmosphere and the under one 84.3°C.

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[1] Montsinger and Cooney, *J. of A.I.E.E.*, Sept., pp. 803–812, 1924.

[2] Rice, "Free Convection of Heat in Gases and Liquids," presented at A.I.E.E. Convention at Philadelphia, Feb. 1924. This value also agrees with the value deduced from Lorentz' formula which was tested out by Langmuir. See *Trans. Amer. Electrochem. Soc.*, **23**, 299–332 (1913).

[3] Smithsonian Tables, value of solar constant for Mount Whitney.

Next consider the case where there is free convection from the lower surface. According to Langmuir,[1] K for the under surface is just one-half K for the upper surface.

Reasoning as before the equations are

$$\alpha\,(T_1-T_2)=C(T_2^4-T_3^4)+=K/2(T_2-T_3)^{5/4} \qquad (c)$$

$$E=C(T_1^4-T_3^4)+K(T_1-T_3)^{5/4}+(T_1-T_2)\alpha \qquad (d)$$

Solving these equations for the case of porcelain we have as before:

$T_1=88.6°C$ and $T_2=77°C$

In the case of Pyrex, however, the absorption of the solar radiation is small and will not be in the surface of the material but distributed throughout the body. The conduction factor can almost practically be eliminated.

However, in order to determine just what per cent of the solar heat was absorbed in Pyrex glass, measurements were made in clear air on direct sunlight. For purposes of comparison, samples from two insulator glasses on the market at the present time were also measured. The curve shows the results for Pyrex and the two glasses. It is evident that the absorption of Pyrex is no more than 5%, the loss for zero thickness being reflected light. The data are plotted both on per cent transmission and on a logarithmic scale, the latter being straight lines.

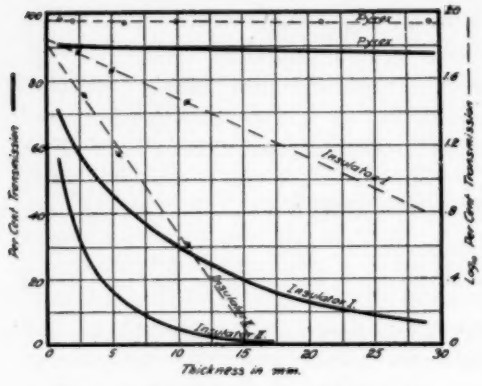

FIG. 1.—Percentage transmission; various insulator glasses.

However, assuming an absorption of 10% in Pyrex, the above equations applied to Pyrex give a temperature of 46.5°C, or a rise in temperature of 6.5°C.

The temperature of porcelain as mentioned above was found to be 88.6°C or a rise of 48.6°C. The ratio of the rise above atmospheric temperature of porcelain to the rise of Pyrex is then 7.5 to 1.

Comparative Measurements of Pyrex and Porcelain Temperatures

Some observations were made on Pyrex and porcelain temperatures in sunlight.

Small light thermocouple wires were cemented on with Dupont cement to the surfaces of porcelain and Pyrex disks. (Dupont cement

[1] Rice, *loc. cit.*

was found to have almost no absorption.) The disk surfaces were approximately normal to the sun's rays. The table shows the final temperatures obtained. The air was by no means quiet at the time of taking the observations and convection served to keep the values of the temperature down.

TABLE I

	Maximum observed temperature rise	
	Front surface	Back surface
Pyrex	2.7°C	2.9°C
Porcelain	20.2	13.4
Insulator glass No. 1	8.1	7.9
Insulator glass No. 2	12.0	11.8

Shade temperature 13.5°C
Date, May 5

The porcelain and Pyrex samples were irregular-shaped pieces of similar size and thickness from insulator skirts. The other insulator glasses were small disks approximately 0.4 cm. thick and 2.5 cm. in diameter. It is to be noted that the Pyrex sample is not as hot on the upper surface as on the lower one.

The next test was made May 13 on large pin type insulators approximately of 44,000 volt rating.

The temperature increases were

	Top	Petticoat
Pyrex	0°C	0°C
Porcelain	19.7	1.7

Shade temperature was 22°C; the temperatures were taken after an hour and a half exposure.

Experiments in Intensified Sunlight

In order to determine further just what temperature Pyrex would be when porcelain was at 100°C and what temperature porcelain would be when Pyrex was at 100°C, the following experiments were made at Fort Pierce, Florida. A representative of the Electrical Testing Laboratories of New York City assisted in this experiment and took all the measurements.

Description of Tests The general scheme employed was to mount the insulators to be tested at the focus of a large tinned sheet metal reflector set up in the open and facing the sun, the idea being to get as high, and therefore as extreme, temperatures as possible.

The articles tested were Pyrex glass insulators and porcelain insulators of two general sizes. The large glass insulator and the large porcelain insulator were slightly different, but the small glass insulator and the small porcelain insulator were sufficiently alike to be identical for the purpose of this investigation.

The reflectors were designed by G. S. Fulcher and constructed of ordinary tinned sheet iron and were built up of 32 sectors. The general dimensions are shown in Fig. 2. The reflectors could be rotated in two planes for focussing and could be accurately pointed by means of the shadow cast by the insulator.

The temperatures were measured by means of copper-advance thermocouples of about No. 32 B & S wire cemented to the surface of the insulators with sodium silicate. Any absorption by this cement would tend to increase the temperature of the Pyrex relatively more than that of the porcelain and accordingly it was not deemed necessary to apply a correction for this absorption.

The thermocouples were located at four points on the large insulators, namely: top, right, and left sides and under the petticoat at the bottom of the groove. On the small insulators, the couples were located on each side and on the top.

Temperatures were measured by means of a Leeds and Northrup portable potentiometer type indicator and were observed at frequent intervals, care being taken that the insulators were kept in focus as the direction of the sun's rays shifted. Three sets of observations were made, the first with the large Pyrex and the large porcelain insulators on metal pins, the second with the small Pyrex and small porcelain insulators on wooden pins, and the third with the large insulators used in the first test but on wooden pins instead of metal pins.

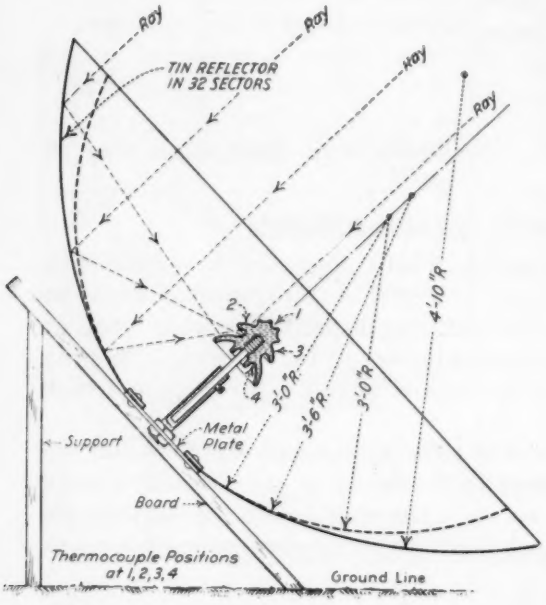

FIG. 2.

Three tests were made with the large insulators on metal pins. In the first and third tests the porcelain insulator was in reflector No. 1 and the Pyrex insulator in reflector No. 2, while in the second test the Pyrex insulator was in reflector No. 1 and the porcelain insulator in reflector No. 2. Two tests were made with the small insulators using wooden

pins. The first test was made with the Pyrex insulator in reflector No. 1 and the porcelain insulator in reflector No. 2, and the second test was made with the Pyrex insulator in reflector No. 2 and the porcelain insulator in reflector No. 1. Two tests were made with the large insulators using wooden pins, the tests being made in the same order as were the tests on the small insulators.

The tests were made at Fort Pierce, St. Lucie County, Florida, and at approximately sea level. The atmosphere was approximately dust free but at times showed haze, which quite noticeably affected the results.

After completion of the tests, the insulators and the temperature indicator with the thermocouples were shipped to the Electrical Testing Laboratories where the latter were calibrated.

Observations

The following table summarizes the final results. It shows the maximum temperatures attained by the insulators in the six tests and the mean ratio in each test of the rise of temperature of the porcelain insulator to the rise of temperature of the Pyrex insulator.

Test no.	Max. mean temp. °C		Mean ratio of porcelain and Pyrex temp. rise
	Porcelain	Pyrex	
1. Large insulators on metal pins	151 (No. 2)	78 (No. 1)	3.05
2. " " " " "	128 (No. 1)	64 (No. 2)	3.6
3. Small " " wooden "	136 (No. 2)	66 (No. 1)	3.5
4. " " " " "	162 (No. 1)	77 (No. 2)	3.15
5. Large " " " "	136 (No. 2)	61 (No. 1)	3.7
6. " " " " "	135 (No. 1)	55 (No. 2)	4.1
		Mean (Arithmetic)	3.5

The observations taken during the different tests are plotted in Figs. 3, 4, and 5. The temperatures that are plotted are the mean temperatures of all the different thermocouples.

There is not much difference between the mean temperatureof the thermocouples and the maximum reading of any one thermocouple in the case of Pyrex insulators but in the case of porcelain these differences were quite high. That is to say, at no time were there any large temperature gradients existing in the Pyrex. This was not the case with porcelain as one

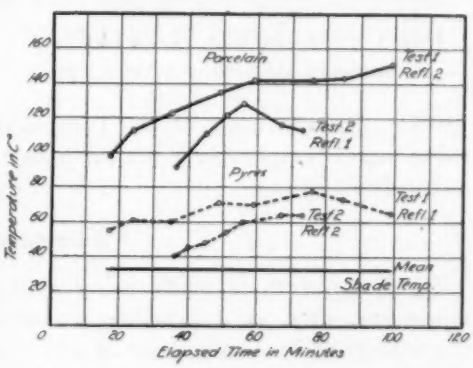

FIG. 3—Temperature curves for large insulators mounted on metal pins.

part of the porcelain would become very much hotter than another portion. The highest temperature observed during the observations at any one point in the porcelain was 185°C.

The simultaneous observations of Pyrex and porcelain taken during all the tests are given in Fig. 6. In this curve the rise of temperature of the porcelain above shade temperature is plotted on one coördinate and the simultaneous rise of the Pyrex is the other coördinate. The curve is drawn through the mean position of the points and has a slope of 3.5. This means that the increase of temperature of the porcelain above atmospheric temperature is 3.5 times the increase of Pyrex. This ratio is somewhat less than the computed ratio. This is probably due to some warming up in the air within the reflector and to some absorption of heat by the thermocouple from the light. In addition the selective reflection of the tin reflector favored the porcelain in all these tests.

The curve given in Fig. 6 or the ratio 3.5 can be used to determine the relative temperature of Pyrex and porcelain under any assumed set of conditions. As an illustration, if atmospheric temperature be assumed to be 40°C (104°F) and the solar conditions such that the porcelain insulator is at 100°C (212°F), that is 60°C (108°F) above atmospheric temperature, the Pyrex insulator will then be approximately 17°C (30.6°F) above atmospheric temperature or at a temperature of 57°C (134.6°F). If conditions are such that the Pyrex insulator is at 100°C, the rise being 60°C, the porcelain rise will be 210°C, the actual temperature being 250°C. On the basis of the computations of possible temperatures these latter temperatures are far above what might be possible under natural conditions.

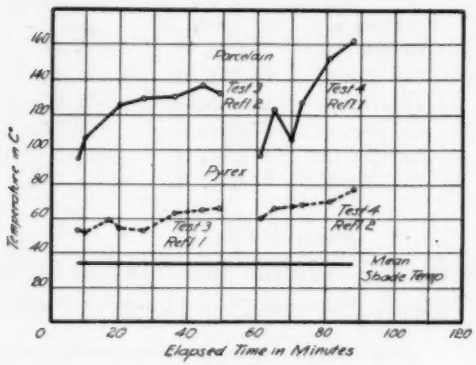

FIG. 4.—Temperature curves for small insulators mounted on wooden pins.

Summary

(1) Computations made using standard radiation and convection equations, give as a possible temperature for a black body when the atmospheric temperature is 40°C (104°F), a temperature of 93°C (199°F). Under these same conditions Pyrex will reach a temperature of 46.5°C (116°F).

(2) Solar heat transmission curves for Pyrex and two commercial insulator glasses have been obtained.

(3) Measurements of the rise of temperature in sunlight of small plates of two insulator glasses and porcelain have been made.

(4) The 44,000 volt porcelain insulator was found to rise in 1½ hours in sunlight 19.7°C (35.5°F). Under the same conditions Pyrex insulators showed no temperature increase whatever above atmospheric temperature.

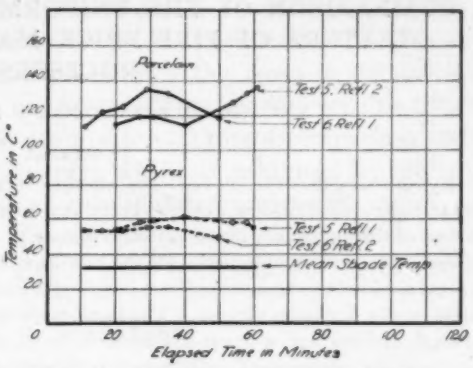

FIG. 5.—Temperature curves for large insulators mounted on wooden pins.

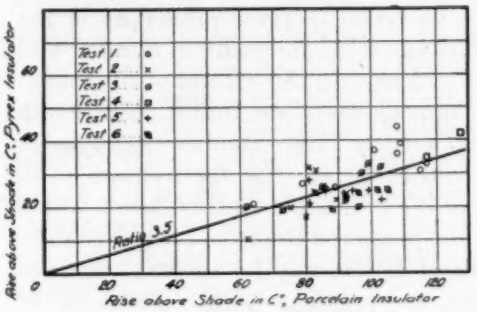

FIG. 6.—Relation between temperature rises of Pyrex and porcelain insulators.

(5) Measurements made at Fort Pierce, Florida, in concentrated sunlight give in a range of temperature up to 160°C, and increase of temperature of porcelain 3.5 times that of Pyrex.

* * *

The authors wish to express at this time their appreciation for the assistance of F. M. Farmer, Chief Engineer of the Electrical Testing Laboratories, and William A. Mahar of the Electrical Testing Laboratories, who assisted in the experiments at Fort Pierce, Florida.

PHYSICAL LABORATORY
CORNING GLASS WORKS
CORNING, N. Y.

A COMPARISON OF THE UNIFORMITY OF STRENGTH AND TEXTURE OF FIRE BRICK MADE BY DIFFERENT PROCESSES[1]

By A. E. R. Westman[2] and W. H. Pfeiffer[3]

ABSTRACT

By assuming that the "deviations from the average" of the strengths and permeabilities of individual bricks of any one brand are governed by the laws of chance, a comparison of the uniformity of strength and texture of a number of brands of brick made by different processes is obtained. Of the brands examined, those made by the stiff-mud process are found to be more uniform in strength and less uniform in structure than those made by the dry-press process. The hand-made bricks show quite a variation in both strength and texture, whereas one brand of brick made by a semi-dry process (English type machine) shows good uniformity in both strength and texture.

I. Introduction

It is the aim of the firebrick manufacturer to produce fire brick which are uniform in strength and texture. In spite of his efforts, however, there is a considerable variation in these properties in the finished bricks. The causes of this variation are many in number and are for the most part fortuitous and beyond the control of the manufacturer. It seems reasonable to assume, therefore, that if the strength or some other property of a sufficiently large number of bricks of one brand were measured, it would be found that the frequencies of the deviations from the average of the individual measurements would have the distribution that would be predicted from the laws of chance. If distribution curves were obtained in this way for several brands of brick made by different processes, a comparison of the shapes of the curves would enable one to decide which manufacturer or method of manufacture produced the most uniform product.

The number of measurements that would be required for the procedure described above make it impracticable. However, if we are willing to assume that the deviations from the average of the strengths and permeabilities of the individual bricks are governed by the laws of chance, it is possible to make a fairly accurate comparison by making measurements on ten or more bricks of each brand.

In connection with an investigation of checker brick for carbureters of water-gas machines, which is being carried on at the University of Illinois,[4] it was necessary to make a large number of measurements

[1] Received June 8, 1926.

[2] Research Associate, Dept. of Ceramic Eng., Univ. of Ill.

[3] Research Assistant, Dept. of Ceramic Eng., Univ. of Ill.

[4] C. W. Parmelee and A. E. R. Westman, "An Investigation of Checker Brick for Carbureters," *Jour. Amer. Ceram. Soc.*, 9 [5], 290 (1926).

of the transverse strength and permeability of samples of a number of brands of brick. Since the permeability of a fire brick, depending as it does on both the number and diameter of the pores in the brick, is very sensitive to changes in texture, the data made available by this investigation afforded an opportunity for making a comparison of the uniformity of strength and texture which is exhibited by different brands of brick and by bricks made by different processes.

In this paper, the method of analysis which was used in making this comparison and the results which were obtained will be described.

II. Data Available

Transverse Strength The moduli of rupture of fifteen samples of each of fifteen brands of fire brick were available. These had been measured in accordance with the A.S.T.M. method for building brick (C21–20) except that the bricks had been broken on edge instead of flat, as checker brick are ordinarily placed on edge in a carbureter. The transverse strength, method of manufacture, etc., of the fifteen brands are shown in Table I. It will be seen that the fifteen brands included a great variety of fire brick.

Permeability Permeability measurements on ten samples of each of nine brands of brick were available. These had been made by means of a permeameter developed in these laboratories, which will be described in a forthcoming circular of the University of Illinois Engineering Experiment Station.

A schematic diagram of the essential parts of this apparatus is shown in Fig. 1. The brick to be measured is clamped against the felt gasket (G) and mercury (H) used to seal the sides of the brick. A steady stream of air is forced through the capillary tube (CT) of the flowmeter (F) and then escapes through the brick. A pressure gage (PG) is used to measure the pressure drop across the brick. In making a measurement, the stream of air is adjusted until the pressure gage indicates a pressure drop of 1 cm. water heat 4°C and then the manometer (M) of the flowmeter is read at minute intervals until a constant reading is obtained. The flowmeter (F) has been calibrated so that it is possible to convert the manometer

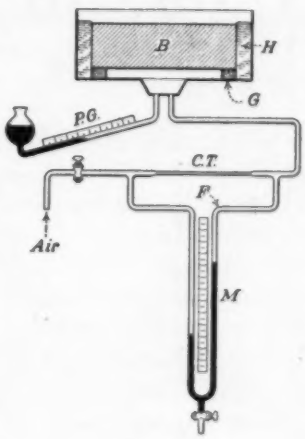

FIG. 1.

readings directly to air flow rates in terms of cc/sec. Thus the rate of air flow through a brick which corresponds to a pressure drop of 1 cm. head of water is obtained. Corrections are applied, when necessary, for the difference between the dimensions of the brick and those of a true standard straight (9 x 4.5 x 2.5 inches) and the value obtained taken as the permeablity of the brick.

III. Analysis of Data

The Per Cent Dispersion of the Average

The problem of making a comparison of the uniformity of strength of the various brands of brick is the same as that of making a comparison of their uniformity of texture or permeability.

Let us consider the case of brand 15, Table I. For this brand we have given the values of the permeabilities of ten samples, as shown in the first column of Table II, in the order in which the measurements were made. The problem resolves itself into a matter of calculating a number from these values which can be used in comparing the uniformity of this brand with that of other brands.

TABLE I
DATA CONCERNING BRANDS OF BRICK MEASURED

Brand number	Transverse strength (average of 15 samples) lbs. per sq. in.	Permeability (average of ten samples) cc/sec/cm press	Permeability (average of three samples) cc/sec/cm press	Method of manufacture	Raw materials
1	434	4.5		H.M.	Flint and plastic clays
2	426	2.01		D.P.	Cheltenham plastic clay
3	731		300	H.M.	Georgia kaolin
4	843		0.38	H.M.	N. J. plastic clay
5	717	2.9		H.M.	Flint and semi-flint clays
6	1243	0.46		S.M.	Semi-flint clay
7	972		5.7	S.M.	Grog, flint, and plastic clay
8	329	7.6		D.P.	Second grade semi-flint and plastic clays
9	576		6.3	D.P.	Pa. clay
10	1316	1.34		S.M.	Semi-flint clay
11	1245	0.69		S.M.	Plastic clay
12	1478		0.49	S.M.	Flint and semi-flint clays
13	1804		0.64	S.M.	Second grade semi-flint and plastic clays
14	730	5.4		S.M.	Flint and plastic clays
15	911	0.27		S.D.P.	Flint, semi-flint, and plastic clays

H.M.—hand mold
S.M.—stiff mud
D.P.—dry press
S.D.P.—semi-dry press

The theory of errors[1] provides us with a means of calculating the "per cent dispersion of the average" for such a series of measurements. In the case we are considering, if such a quantity has the value "d," it indicates that, if the permeabilities of ten more samples were measured and their average permeability were calculated, the new average would be as liable to be within $d\%$ of the average of the first ten bricks as to be outside of these limits. Such a quantity is sometimes called the "probable per cent error of the mean." It is evident that, if an equal number of samples of two different brands of brick were measured, the relative magnitudes of the values obtained for the per cent dispersions of the average of these two brands would depend on their relative uniformity, provided the laws of chance are applicable. The more uniform brand will, in general, have a smaller per cent dispersion of the average. If, then, we calculate the per cent dispersions of the average for each of the brands of brick under consideration, we shall be able to make a comparison of their uniformities, as the more uniform brands will have a smaller number for this quantity.

Calculation of the Per Cent Dispersion of the Average

The per cent dispersion of the average is calculated as shown in Table II.[1] Column 2 of this table gives the values of the permeabilities arranged in order of magnitude; column 3 gives the deviations of these values from the average (0.261), and column 4 gives the squares of these deviations. If the square root of the sum of the numbers in column 4 is multiplied by 0.6745 and divided by $\sqrt{n(n-1)}$, where n is the number of measurements, the dispersion of the average (0.0071) is obtained. If this is calculated as a percentage of the average (0.261), the per cent dispersion of the average (2.7) is obtained. In actually carrying out these calculations, tables which greatly simplify them can be used.[2]

Chauvenet's Criterion

In a small number of samples, there is apt to be one brick which is so very permeable or impermeable that the inclusion of its value in the calculations would have a very disproportionate effect on the quantities calculated. In order to prevent this, it is conventional procedure to discard a measurement if its deviation from the average is greater than a value calculated by means of Chauvenet's criterion. This value is obtained by multiplying the dispersion or the square root of the sum of the numbers in column 4 by factors which depend on the number of measurements under consideration. These factors are given in practically all texts on theory of measurements. In the example in Table II, the value of the criterion is 0.65 and as the largest deviation is 0.46, none of the measurements was discarded.

[1] Consult texts on Theory of Measurements.

[2] See "Theory of Measurements," by Palmer, McGraw-Hill, (1912).

TABLE II

SAMPLE CALCULATION (Brand 15, Table I)

Permeability (1) P	Permeability (2) P	Deviation from average (3) v	Squares of deviations from average (4) v^2
0.239	0.217	−0.044	0.001936
0.299	0.221	− 40	1600
0.276	0.234	− 27	729
0.248	0.239	− 22	484
0.307	0.248	− 13	169
0.217	0.276	+ 15	225
0.284	0.284	+ 23	529
0.221	0.288	+ 27	729
0.234	0.299	+ 38	1444
0.288	0.307	+ 46	2116
Average	0.261	Total	0.009961

Chauvenet's criterion $= 0.654 \times 0.0998 = 0.065$

Dispersion of average $= 0.6745\sqrt{\frac{\Sigma v^2}{n(n-1)}} = 0.0071$

% dispersion of average $= \frac{0.0071 \times 100}{0.261} = 2.72\%$

TABLE III

UNIFORMITY OF TRANSVERSE STRENGTH

Brand number	% dispersion of average transverse strength (15 samples)	Method of manufacture: Semi-dry press	Stiff-mud repress	Dry-press	Hand-mold
*1	5.08				X
*2	4.98			X	
3	4.47				X
4	4.03				X
*5	3.95				X
*6	3.78		X		
7	3.28		X		
*8	2.94			X	
9	2.86			X	
*10	2.81		X		
*11	2.65		X		
12	2.03		X		
13	1.94		X		
*14	1.92		X		
*15	1.76	X			
Average % dispersion		1.76	2.63	3.59	4.38

Uniformity increasing →

IV. Results of the Analysis

From the data which were available, the per cent dispersions of the average transverse strength were calculated for fifteen different brands

of brick and are shown in Table III, column 2.[1] The calculations, in the case of each brand, were based on measurements of fifteen bricks whose strengths were within the limits of Chauvenet's criterion. The method of manufacture of each brand is indicated in the table. It is evident that, for the brands considered, the methods of manufacture in order of decreasing uniformity of transverse strength are: semi-dry press (av. 1.76), stiff-mud repress (av. 2.63), dry press (av. 3.59) and hand mold (av. 4.38).

TABLE IV

UNIFORMITY OF PERMEABILITY

Brand number	% dispersion of average permeability (ten samples)	Method of manufacture: Semi-dry press	Stiff-mud repress	Dry-press	Hand-mold
6	8.8		X		
5	8.5				X
14	8.3		X		
10	8.0		X		
11	5.9		X		
1	4.8				X
2	3.1			X	
15	2.7	X			
8	2.5			X	
Average % dispersion		2.7	7.8	2.8	6.7

Uniformity increasing →

Similar calculations were made using the results of permeability measurements on ten samples of each of the nine brands indicated by an asterisk in Table III. The results of these calculations are shown in Table IV, column 2.[2] As in Table III, the method of manufacture of the different brands is indicated. It is evident that, for the brands considered, the methods of manufacture, when arranged in order of decreasing uniformity of permeability or texture, are: semi-dry press

[1] The inherent errors in the method of measurement make these values somewhat larger than those that would be obtained with a method that was absolutely exact. If the magnitudes of the inherent errors of the method used are known, corrections can be applied by the method of Shewhart, *Bell System Technical Journal*, 5 [1], 11–26 (1926). In the present case these corrections are small and as only comparative results were wanted, they were omitted.

(av. 2.7), dry press (av. 2.8), hand mold (av. 6.7) and stiff-mud repress (av. 7.8). Thus the order of uniformity of texture is quite different from the order of uniformity of transverse strength, the more permeable bricks being more uniform in texture than the less permeable bricks and less uniform in transverse strength.

V. Summary

An analysis of data on the transverse strength and permeability of a number of brands of fire brick has been made in such a way that it is possible to make a comparison of the relative uniformity of strength and texture of different brands of brick and of bricks made by different processes.

Insofar as the brands examined are representative of fire brick in general, it is shown that:

(1) Different brands of fire brick differ greatly in uniformity of both strength and texture.

(2) Named in order of decreasing uniformity of transverse strength, the methods of manufacture are: semi-dry press, stiff-mud repress, dry press, and hand mold.

(3) Named in order of decreasing uniformity of permeability or texture the methods of manufacture are: semi-dry press, dry press, hand mold, and stiff-mud repress.

(4) As only one brand of brick made by the semi-dry process was examined, its correct position in the series in conclusions (2) and (3) is not as definitely known as that of the other methods of manufacture.

The writers are indebted to C. W. Parmelee, Head of the Department of Ceramic Engineering, for his interest and help.

KERAMEUS OF A WORKER IN GLASS[1]

By W. A. Oldfather

The question of the linguistic correctness of the extension of the word 'ceramic' (from Greek *keramos*) to include the glass industry, has been the subject of two short articles in this *Journal*.[2] The case as there argued, in the almost complete absence of direct testimony, depended largely on inference. It is a pleasure to add to the positive evidence the artist's signature on a glass medallion[3] from early imperial times,[4] now preserved in the Museo Cristiano at Brescia, **BOYNNEPI KEPAMI,** *i.e.*, "Bounneri the potter" (*kerami* being merely late dialectic Egyptian Greek for *kerameus*).[5] In other words, the artist of this remarkable piece of painting on glass calls himself a *kerameus*, showing clearly that in late antiquity, at least, it was perfectly possible to apply a derivative of *keramos* to a worker in glass.

Urbana, Ill.

[1] Received June, 1926.

[2] *Jour. Amer. Ceram. Soc.*, **3** [7], 526 (1920), especially pp. 537–42; and *Ibid.*, **7** [4], 114–16 (1924).

[3] The most recent and accessible publications of this medallion are those by R. Garrucci, *Vetri Ornati di Figure in Oro Trovati nei Cimiteri dei Cristiani di Roma.* 2nd ed. Rome 1864, pl. XLII, no. 7; Gerspach, *Revue de l'Art Chrétien*, 1899, p. 50; A. Venturi, *Storia dell' Arte Italiana*, Milan 1901, I, 361, 405; S. Reinach: *Repertoire des Peintures Grecques et Romaines*, Paris, 1922, p. 333, 18; finally, and most elaborately, by F. de Mély, "Le Médaillon de la Croix du Musée Chrétien de Brescia," *Arethusa* **3**, 1–10 (1926).

[4] The general view has been that it dated from the fifth century after Christ. M. de Mély (apparently with the agreement of Wilhelm Froehner) argues for the third. The rash opinion of R. Garrucci that it is a forgery is amply refuted by the latest authority after detailed study. Wilhelm Froehner (quoted by De Mély, p. 9) thinks it may have been manufactured in Rome in the shop of a Jewish Christian glass worker from Egypt; but this opinion seems a bit speculative.

[5] According to M. E. Crum of the British Museum, quoted by De Mély, p. 6, who adds that it is also the ordinary word for potter in Coptic, derived of course from the Greek. The personal name is probably related to the proper noun "Bouni," in Wessely *Studien*, **10**, p. 156, No. 296, 16, of the seventh or eighth century after Christ, from Egypt, rather than to the "barbarian" names "Bounia," "Bounis," "Bounific . . . . ," of northern Italy and Noricum (*CIL* III 11481 and 11587, and V 7054 and 4169).

EXPLANATION

Explanation of the curves shown in the paper "The Effect of Atmospheric Conditions on the Load Test for Refractories," by L. F. Sheerar, page 279, May, 1926, *Journal of the American Ceramic Society*.

Figures 5 to 13 inclusive should be designated as follows:

FIG. 5.—Effect of oxidizing atmospheres at high temperature on soft-mud specimens containing varying amounts of iron pyrite.

FIG. 6.—Effect of neutral atmosphere at high temperature on soft-mud specimens containing varying amounts of iron pyrite.

FIG. 7.—Effect of reducing atmosphere at high temperature on soft-mud specimens containing varying amounts of iron pyrite.

FIG. 8.—Effect of oxidizing atmosphere at high temperature on stiff-mud specimens containing varying amounts of iron pyrite.

FIG. 9.—Effect of neutral atmosphere at high temperature on stiff mud specimens containing varying amounts of iron pyrite.

FIG. 10.—Effect of reducing atmosphere at high temperature on stiff mud specimens containing varying amounts of iron pyrite.

FIG. 11.—Effect of oxidizing atmosphere at high temperature on dry-press specimens containing varying amounts of iron pyrite.

FIG. 12.—Effect of neutral atmosphere at high temperature of dry-press specimens containing varying amounts of iron pyrite.

FIG. 13.—Effect of reducing atmosphere at high temperature on dry-press specimens containing varying amounts of iron pyrite.

In each figure the upper curve denotes the temperature treatment. The other curves reading from the bottom up, *at the completion of the test* are low iron content, medium iron content and high iron content.

CERAMIC ABSTRACTS

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[1] The abbreviation (*C. A.*) at the end of an abstract indicates that the abstract was secured from *Chemical Abstracts* by coöperative agreement.

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Abrasives

PATENT

Nonslip tile. L. R. H. MINTON. U. S. 1,589,411, June 22, 1926. A nonslip surface having granular rutile embedded therein as a nonslip element.

Art

Standardized proportion of the Greek vase and ornament. R. W. GARDNER. *Jour. Amer. Ceram. Soc.*, **9** [7], 426–36 (1926).—This paper demonstrates that in Greek art geometry and not inspiration was the basis of proportion and the fundamental of design. It gives the actual method, hitherto lost, that was employed in the application of geometry to design by artists and craftsmen of the 5th Century B.C. The subject matter contd. in this article was obtained by its writer in an investigation into the proportions of the Parthenon. In his book "The Parthenon: Its Science of Forms," G. deals only with the temple and the design of the Acropolis and of the city of Athens and its port of the Piraeus, but in this article he gives in a simplified form the canon of proportion which can be applied today in every branch of art, the canon which the Greeks employed in producing the masterpieces of the Golden Age of Pericles.

The manual of old Neiderrheinsche pottery. W. SCHURMEYER. *Keram. rund.*, **134**, 260–64 (1926). H. G. S.

A review of the problems of fine ceramics. K. O. BECK. *Sprechsaal*, **59**, 232–33 (1926). H. G. S.

New glass etching system. ANON. *Amer. Glass Rev.*, **45** [41], 17–18 (1926).—Synlac, Ltd. of London, Eng., producers of a medium for quickly etching glass, call it "Quick-Etch." The work is complete in 3 minutes, performed at room temp., and the resultant etching is claimed to be even and fine-grained. A general description of its use is given. E. J. V.

How stained glass is made. ANON. *Nat. Glass Budget*, **42** [6], 26 (1926).—A general discussion of methods used in the production of painted or stained glass. E. J. V.

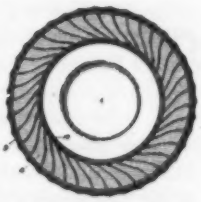
Pottery and glass industries in Italy. ANON. *Pottery, Glass, and Brass Salesman*, **33** [24], 23 (1926).—A brief note on the artistic blown glass and crystal indus. of Italy, whose production is almost entirely for export to Great Britain and the U. S. Czechoslovakia is the most serious competitor and measures are being taken to inaugurate a high protective tariff. The pottery indus. is mentioned. E. J. V.

Pottery styles and periods in Peru. A. L. KROEBER. University of Calif. Publications in *Amer. Archeology and Ethnology*, **21**, Pts. 5 and 6. O. P. R. O.

Painted pottery from Mesopotamia. W. F. ALBRIGHT. *Nature*, **117**, 464 (1926).—Interesting results obtained from a surface examn. of the mounds in the middle Euphrates region throw a light on the comparative ceramics of the aeneolithic and early bronze periods. The site of the finds, Tell Zeidan, is a mound about 500 meters in length, stretching along the eastern bank of the Balikh river. It is covered with potsherds and flint artefacts, the former being nearly all of a creamy white or light buff, covered with geometric designs in black or reddish-brown, applied both with or without a slip, in the former case on the buff ware. Only one polychrome shred was found; it showed alternating bands of black and brownish-red on a white slip over a light buff paste. The result of comparison of this pottery with that from the various other sites in which the proto-Mesopotamian ware has been found, and a study of the mat. as a whole, suggests a similarity which almost amts. to an identity, in all the pottery from northwestern Mesopotamia, Babylonia, and southern Susiana in the pre-monumental age.
O. P. R. O.

PATENT

Glass dish and art of decorating the same. C. L. REIZENSTEIN. U. S. 1,589,558, June 22, 1926. A transparent dish having a design on the back thereof comprising a plurality of adjoining curved surfaces and an opaque coating applied to said surfaces.



Cement, Lime, and Plaster

Investigation on enamel clays. V. W. BOEKER. *Jour. Amer. Ceram. Soc.*, **9** [7], 399–411 (1926).—Functions of clay in enameling and requirements of enamel clays are enumerated. The investigation deals with 12 representative enamel clays, which were examd. for water of plasticity, drying shrinkage, modulus of rupture, and properties when fired to 1000°C. Using these clays in enamel slips, viscosity, suspension test, and hydrogen-ion concn. by the indicator method were run. Fineness test, petrographic examn. and chem. anal. were made on the clays. They were then tested in a cover-coat enamel, subjecting the test pieces to impact test and thermal shock. The results of all the tests are summarized and conclusions drawn therefrom.

Gypsum-sulphuric acid process. W. J. MÜLLER. *Z. angew. Chem.*, **39**, 169–74 (1926); *Chem. and Ind.*, **45B**, 271 (1926).—Gypsum is reduced by coke at 800°, according to the equation $CaSO_4+C=CaO+SO_2+CO$. Clay is added to the raw mats. in the propns. requisite to make Port. cement. An oxidizing atm. must be maintained to prevent formation of CaS in the clinker and of CO in the gases. In practice, about ⅓ the theoretical quantity of coke is used, in order to prevent too rapid reduction. The Port. cement produced is of good quality, and is ground with blast fur. slag and sold as blast fur. cement. The gases from the kiln contain 7 % SO_2 and after elec. pptn. of dust and washing, are used to make H_2SO_4. H. H. S.

Aluminous cements. G. AGDE AND R. KLEMM. *Z. angew. Chem.*, **39**, 175–86 (1926); *Chem. and Ind.*, **45B**, 275 (1926).—Vogel mountain bauxite can be used for making cement which falls within the field of alumina cements on the Gibbs triangular system,

and for a series of products covering the range from alumina to Port. cement. Microscopical examn. shows the cements to consist of an amorphous groundmass together with crystals of melilith; on setting, the amorphous mat. is converted into a mass of interlocking crystals, which probably accts. for the quick setting of the cement. CaO and Al_2O_3 then go into soln.; colloidal Al_2O_3 and SiO_2 are deposited as reactive gels, which are converted into silicates, aluminates, and aluminosilicates, thus causing the hardening of the cement. Mats. with high CaO set rapidly, but have no subsequent strength. Aluminous cements are very resist. to acids (10% $KHSO_4$) unless Fe content is high, and to $MgSO_4$ solns. H. H. S.

Some properties of Lumnite cement. L. J. ROTHGERY. Mich. Eng. Expt. Sta., *Bull.*, No. 4 (1926).—R. describes the effect of freezing upon the setting, hardening, and strength of Lumnite cement. Lumnite cement concrete subjected to freezing immediately after mixing failed to stand a satisfactory test. This same concrete when allowed time for hydration after thawing attained a strength slightly below that of samples cured under normal conditions. Concrete subjected to freezing after the final set had occurred attained its usual 24-hour strength. In general the ultimate strength of concrete made with Lumnite cement is not affected by freezing. Suggestions are made for the protection of concrete placed during freezing weather. A study was also made of the bond between Port. cement and Lumnite cement under varying conditions. (*C. A.*)

Cements. F. KÜMMELL. *Pharm. Ztg.* **71**, 509–10 (1926).—A discussion of various mat. and prepns. designed to cement or repair certain metals, enameled ware, glass, porcelain, stone, and stoneware, wood, leather, celluloid, etc., together with an enumeration of the necessary formulas. (*C. A.*)

Enamels

New investigations on enamels. E. URBSCHAT. *Keram. rund.*, **34**, 259–60 (1926).—U. claims that (1) a freshly prepd. H_2SO_4 bath acts better than one contg. Fe_2SO_4; (2) no advantage is gained by mixing an old acid soln. with a new one; (3) increasing the Fe_2Cl_3 concn. in a HCl bath hastens the reaction; (4) increasing the temp. of the bath hastens the reaction; (5) Fe heated at red heat before treating in an acid bath loses 300–400% more than unheated Fe; (6) the addition of HCl or NaCl to a H_2SO_4 bath retards the action of the bath. H. G. S.

Sand blast sand. W. M. WEIGEL. *Nat. Glass Budget*, **42** [8], 11 (1926).—Definitions of sand are discussed. Sand blast sand requires most uniformly sized grains. Uses of the sand blast and classifications of different sizes of sand blast sand are discussed together with the relative merits of rounded grains and sharp, angular grains. E. J. V.

Influence of number and size of particles on covering power. C. KÜHN. *Farben Ztg.*, **31**, 1131–33 (1926); *Chem. and Ind.*, **45B**, 287 (1926).—Opacity is proportional to number of particles per unit vol., the relative dimensions of the particles not affecting opacity within certain limits, but the rate of increase of opacity with increase in the number of particles per unit vol. is more rapid in the case of the finer particles. H. H. S.

Antimony oxide. ANON. *Chem. Trade. Jour. & Chem. Eng.*, **77**, 356 (1925).—Invests. have been made by Wohlgemuth and Rewald into the use of antimony oxide in the enameling indus., where it has largely replaced tin oxide in recent years. Expts. on various frits made from a commercial oxide free from arsenic, lead, barium, and zinc, led them to the conclusion that such an oxide is absolutely innocuous even when forming part of glazes on cooking utensils. O. P. R. O.

The employment of case iron and acid-resisting enamels in the construction of apparatus. B. LIEBING. *Apparatebau*, **38**, 49–50, 61–63, 73–74, 85–87 (1926).—High-Si cast Fe, Ni, Cr and Mn alloys, acid and heat-resisting enamels and enameled app., with methods of making tight joints, are discussed. (*C. A.*)

The use of cast iron in the construction of apparatus. W. DENECKE AND TH. MEIERLING. *Apparatebau*, **38**, 97–103 (1926).—A discussion of the properties and constituents of cast Fe and the effects of heat on them, with 9 photomicrographs and 12 cuts of app. (*C. A.*)

Glass

A non-actinic cobalt-blue glass. W. W. COBLENTZ AND A. N. FINN. *Jour. Amer. Ceram. Soc.*, **9** [7], 423–25 (1926).—A non-actinic blue glass is described. The substitution of cerium oxide for a part lime and the addition of a small amt. of cobalt oxide in an ordinary soda-lime glass produces a glass which, in 5 mm. thickness, absorbs practically all the ultra-violet rays. The compn. of the glass, its ultra-violet absorption, and the visible spectral transmission are given.

The function of arsenic in soda-lime-silica glasses. E. M. FIRTH, F. W. HODKIN, M. PARKIN, AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **9** [37], 3–19 (1926).—Reviews lit. on use and opinions as to functions of arsenic in glasses. Series of pot melts made to det. degree of retention of arsenic by glass and the action of arsenious oxide used in glass batches on the melting, refining, and color of the glass, showed that from batches melted without oxidizing agents at 1400°C, nearly all the arsenic was retained in the glass when the batch contd. up to 50 parts arsenious oxide per 1000 parts of sand, while 60% or more was retained when the batch contd. up to 250 parts of arsenious oxide per 1000 of sand, from 40 to 70% of the arsenic being retained in the pentavalent condition. There was no definite rel. between the amt. of arsenic used and that retained by the glass. Evidence as to the effect of ordinary commercial amts. of arsenic on the rate of melting of the batch was inconclusive, but use of excessive amts. of arsenious oxide caused greatly increased difficulty of melting, and some melts with low arsenic content showed tendency to scum. Melts showed no evidence of any favorable action of arsenic on the refining rate of the glass. With increase in the amt. of arsenious oxide used, the depth of the iron color in the glass constantly decreased and tended in tint toward the yellow. All meltings were of the same standard soda ash-limestone batch. No data was given as to the normal rate of melting and refining of this batch without arsenic under the conditions of the expts. D. J. McS.

The devitrification of soda-lime-silica glasses containing excessive amounts of arsenic. M. PARKIN AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **9** [37], 20–26 (1926).—Devitrification temps. detd. on samples of glasses contg. excessive amts. of arsenic (from 20 to 250 parts As_2O_3 per 1000 of sand) which in previous expts. had shown tendency to opalescence. Muffle test and heat evolution methods used, but latter did not give consistent results probably owing to slow rate of heat evolution on devitrification. Type of devitrification varied with arsenic content and temp. Glasses from batches contg. 25 parts or less of arsenious oxide per 1000 sand did not differ greatly in action from that of glass from same batch without arsenic. Minimum devitrification temp. was shown by glass from batch contg. 100 parts arsenious oxide per 1000 sand. With glasses of lower arsenic content than this, devitrification took place very slowly from the surface inward; while with glasses of higher arsenic content devitrification took place throughout the mass. A lower devitrification temp. was shown by glass samples which had been heated repeatedly than by samples of the same glasses

undergoing their first htg. The cryst. products of devitrification showed some characs. of wollastonite. D. J. McS.

Glasshouses on the Tyne in the eighteenth century. F. BUCKLEY. *Jour. Soc. Glass Tech.*, **9** [37], 26–52 (1926).—A continuation of B.'s interesting account of the history of glass making in different sections of Eng. D. J. McS.

The effect of composition on the viscosity of glass. Part IV. Calculation of the influence of minor constituents. S. ENGLISH. *Jour. Soc. Glass Tech.*, **9** [37], 52–62 (1926).—By plotting the values, previously obtained by him of the log viscosity of glasses against the percentage of lime replacing soda, and of alumina and magnesia replacing lime in mol. propns., E. shows that for temps. from 900° to 1400°C the curves obtained are practically straight up to 9% of lime, 1.5% magnesia, and 2% alumina, and from these curves he dets. the approx. factors of change in log viscosity at each temp. within this range resulting from the mol. substitution of soda by lime and of lime by magnesia and alumina, within these limits. By applying these factors to soda silica glasses contg. small amts. of lime and alumina, he dets. the approx. viscosity change factors for the mol. substitution of silica by soda. In a similar manner, these factors are converted from a mol. to a percentage basis, and by applying these approx. factors to the viscosities of a number of glasses showing substitution of one component by another, the following precise factors, valid within the limits of substitution given above, for modification of the viscosity by substitution, were obtained:

	Variation of log vicosity					
Replacement of	1400°C	1300°C	1200°C	1100°C	1000°C	900°C
1% Na_2O by 1% SiO_2	+0.040	+0.052	+0.072	+0.083	+0.101	+0.120
1% Na_2O by 1% CaO	+0.080	+0.070	+0.062	+0.056	+0.052	+0.048
1% MgO by 1% CaO	+0.097	+0.052	−0.000	−0.022	−0.007	+0.052
1% Al_2O_3 by 1% CaO	−0.034	−0.024	−0.010	+0.025	+0.090	+0.200

No data is available by which the factors for the iron oxides can be obtained.
D. J. McS.

Glass tank design. A criticism. H. W. HOWES. *Jour. Soc. Glass Tech.*, **9** [37], 66–73 (1926).—H. points out a number of inaccuracies in the article on glass tank design by J. A. Voorhies, *Fuels and Fur.*, **3**, 167 (1925). (See *Ceram. Abs.*, **8** [7], 189 (1925)). D. J. McS.

The composition of glass suitable for use with automatic glass-forming machinery. W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **9** [37], 80–91 (1926).—Ranges of compn. of glasses used in all types of automatic forming machs. are given and compared with glasses for same purposes formed by hand. Bottles can be made with wider range of glass compn. on suction than on gob-feed machs. Glass compn. for bottles should be related to the following factors: the method of charging the blank mold; the speed of the mach.; the size and weight of the article to be made; the shape of the bottle or of special parts of it; the viscosity of the glass at the charging temp.; the setting rate of the glass; its tendency to devitrification; and the rate at which heat is lost by condy. or radiation. Knowledge of the effect of various glass constituents on the viscosity and setting rate of the glass can often allow changes in glass compn. which will strengthen or otherwise improve the glass without affecting its machining character.
D. J. McS.

The influence of boric oxide on the properties of chemical and heat-resisting glasses. Part II. The resistance to chemical reagents. W. E. S. TURNER AND F. WINKS.

Jour. Soc. Glass Tech., **9** [37], 102–13 (1926).—Reviews lit. on effect of boric oxide in glasses on resist. of glass to chem. action. Series of glasses made by substituting in glass of Kavalier formula, increasing amts. of boric oxide for silica. The resist. of the glasses to attack remained practically constant with increase in boric oxide content up to about 11 % in the case of boiling water, about 2 % in the cases of both boiling hydrochloric and of sodium hydroxide. With further increase in the boric oxide content of the glasses, the resist. to attack decreased. From those glasses rich in boric oxide, boiling hydrochloric extracts all the sol. oxides leaving the silica as a skeleton retaining the form of the original glass. D. J. McS.

Glass: a factor in civilization. ALEXANDER SILVERMAN. *Bull. Amer. Ceram. Soc.*, **5** [7], 311–16 (1926).—S. traces the various steps in glassmaking as recorded in the history of foreign nations. He then traces the further developments perfected in America and shows how glass in its various forms has affected our civilization. Its indispensibility to modern civilization is very plainly shown. E. J. V.

Broadcasting the story of plate glass. H. D. TRAVER. *Amer. Glass Rev.*, **45** [37], 31–40 (1926).—The entire process of plate glass manuf. is discussed in considerable detail. A full reprint of an address broadcast by radio. E. J. V.

Colored glass and glass decoration.—(*con.*) JAMES H. GARDINER. *Amer. Glass Rev.*, **45** [37], 19–23 (1926).—Glass decoration in various ways is discussed. Cut glass production by the old process is described. The methods of producing cheaper quality articles by "acid polishing" and the production of pressed ware which is gone over with a wheel are censured. Embossing, "flashing" of thin coats of glass of different colors on a surface and then exposing the various colors by grinding or etching, various methods of deposition of metals on glass, etching designs on glass and lettering or printing in different colors are described in detail. See *Ceram. Abs.*, **5** [6], 177 (1926) and **5** [7], 201 (1926). E. J. V.

Unfavorable situation reported in Czechoslovak glass industry. ANON. *Amer. Glass Rev.*, **45** [40], 16 (1926).—Exports of glass are decreasing due to the imposition of higher customs duties in other countries to protect home industries. Many plants are curtailing production and some have ceased opern. E. J. V.

Efficient manufacturing behind Illinois bottles. ANON. *Amer. Glass Rev.*, **45** [50], 19–21 (1926).—A full description of the largest bottle factory in the world, the Alton, Ill., plant of the Ill. Glass Co., tracing the various steps and discussing the great efficiency of the entire service which makes possible the fulfillment of the boast of the Company, "We supply everything but the formula." E. J. V.

How building glass is bent at Oriel plant. ANON. *Amer. Glass Rev.*, **45** [40], 25–26 (1926).—A full description of the production of bent glass, the exclusive product of the Oriel Glass Co. at St. Louis. Various difficulties encountered are discussed. E. J. V.

The Belgian glass industry prosperous, all branches show satisfactory demand. ANON. *Amer. Glass Rev.*, **45** [40], 55–56 (1926).—Despite exchange fluctuations the glass industry in Belgium, which operates almost exclusively for exportation, is enjoying good business and the outlook continues favorable. E. J. V.

A new way to clean molds. ANON. *Amer. Glass Rev.*, **45** [41], 14 (1926).—A special application of sand blasting app. used at an automatic bottle factory is briefly described. E. J. V.

Glass industry in Germany. ANON. *Amer. Glass Rev.*, **45** [41], 17 (1926).–A discussion of the products of the Thuringian glass indus. and the increase in exports in all

branches thereof in 1925 as compared to 1924. The increase in exports to the U. S. is about 25%. E. J. V.

To make shock-proof glass. ANON. *Amer. Glass Rev.*, **45** [41], 27(1926).—It is reported that a new shock-resist. glass made by special mach. is to be produced in a Czechoslovak factory backed by Italian interests. E. J. V.

Sodium chloride as a possible cause of seeds in glass. A. R. PAYNE. *Glass Ind.*, **7** [7], 153–56(1926).—The study of deposits in seeds in glass bottles made by the Owens process showed them to be sodium chloride and water. Glass was studied in a micro-fur. and the deposits in the seeds watched during volatilization and condensation as the temp. was raised and lowered. Exptl. melts were made, studying the effect of the addition of extra sodium chloride, use of soda ash with as low as .003% NaCl, press., temp., and time in the charac. of deposits. Incomplete heating allowing an appreciable amt. of sodium chloride to remain in the glass will tend to result in the formation of seeds due to the volatilization of the sodium chloride on subsequent heating and working in the revolving pot. Seed-free glass can be obtained if nothing is done to cause the salt to come out of soln. The seeds are formed due to this cause mainly in the Owens opern., but it is certain that for ordinary glass manuf., pressing, gathering, etc., the presence of sodium chloride is without special effect. E. J. V.

The use of cullet in glass manufacture. ERICH FELSNER. *Glass Ind.*, **7** [7], 163 (1926). (Translated from *Keram. rund.*, **34**, 293(1926)).—Cullet must be used with caution in glassmaking. During remelting valuable constituents of the glass are lost by volatilization and the loss must be compensated by the addition of mat. to introduce these constituents. The nature of the glass may be affected by the addition of cullet, as may be the mtg. process. Only pure cullet should be used, a clarifying agent being added to remove impurities. The effect of adding cullet at different points in the mtg. process is discussed and methods of remedying defects suggested. E. J. V.

A new kind of wire glass. ANON. *Glass Ind.*, **7** [7], 174(1926).—Using single strands of wire spaced equal distances apart instead of meshed wire, "Saferlite" is the latest development of the Miss. Wire Glass Co. E. J. V.

New glareproof mirror manufacturing process discovered by the Liberty Mirror Works. ANON. *Nat. Glass Budget*, **42** [7], 3(1926).—A new method of silvering mirrors whereby the glare is absorbed by the silver deposit and not reflected back is announced. Special characs. of the deposits produced by this process are enumerated. E. J. V.

Heat economy of glass tanks. S. R. SCHOLES. *Nat. Glass Budget*, **42** [6], 6(1926).—Reprinted from *Bull. Amer. Ceram. Soc.*, **4** [11], 599–600(1925). E. J. V.

Glass making secret reported. ANON. *Nat. Glass Budget*, **42** [6], 17(1926).—A brief note on the production of flaked glass by coating sandblasted glass with glue and gradually drying it in an oven. E. J. V.

Abrasive sand facts. W. M. WEIGEL. *Nat. Glass Budget*, **42** [8], 13(1926).—Several grades of product classed as abrasive sands are enumerated. Properties of sand used for rough grinding plate glass are discussed. E. J. V.

Discovers cause of and how to eliminate tank lines. DESSENT. *Nat. Glass Budget*, **42** [9], 3(1926).—Tank lines cause great financial losses to window glass companies due to the necessity of throwing away a considerable percentage of glass, inferior quality being produced and small, undesirable sizes being cut to avoid the lines. D. claims to know the cause of these lines and a means for eliminating them. E. J. V.

Corrosion of tank blocks studied by U. S. Bureau. ANON. *Nat. Glass Budget*, **42** [10], 3(1926).—Investigation of the causes of frequent failure of tank blocks showed that the phys. structure was a dominating factor controlling their service life. Blocks should be homogeneous and their pores small, either closed or non-connecting, if possible. Corundum or mullite show the best resist. to soln. E. J. V.

Society of Glass Technology holds annual dinner; Americans are guests. ANON. *Nat. Glass Budget*, **42** [10], 12(1926).—A report of the last meetings for the session 1925–26 at which the following papers were presented: "Glass in Early Ages" by W. M. Flinders Petrie; "Opal Glass" by J. W. Ryde; "The Electrical Conductivity of Glasses at High Temperatures" by F. F. S. Bryson; "The Influence of Moisture on the Rate of Melting and on the Properties of Soda Lime Glasses" by Edith M. Firth, F. W. Hodkin, M. Parkin and W. E. S. Turner. E. J. V.

Jobbers and distributors can use to advantage modern glass carrying equipment in warehouses. J. W. CRUIKSHANK. *Nat. Glass Budget*, **42** [11], 1(1926).—Old manual methods of manipulating large sheets of glass are contrasted with new mech. methods. Various types of mach. now used, as tipping tables, cranes, special clamps which grip an edge, and vacuum clamps applied to the surface of the glass are discussed. E. J. V.

Compares ancient Venetian glass with modern product. ANON. *Nat. Glass Budget*, **42** [11], 6(1926).—(Reprinted from *Christian Sci. Monitor.*)—Venetian glass and methods of manuf. of 300 years ago are compared with their modern product and methods. E. J. V.

Glass industry in Czechoslovakia. ANON. *Pottery, Glass, and Brass Salesman*. **33** [24], 26(1926).—The general situation continues favorable as commercial treaties now in force have secured several advantages. Bohemian glass production has decreased since 1925 due to increasing Amer. competition. Competition of Czechoslovakia and Belgium has placed the Finnish glass industry in a critical state. E. J. V.

Measurements on the thermal expansion of fused silica. WILMER SOUDER AND PETER HIDNERT. Bur. Stand., *Sci. Paper*, No. 524, 23 pp.(1926).—The results of an invest. on the thermal expansion of 17 samples of fused silica, transparent and non-transparent, over various temp. ranges between −125 and +1000°C are given. A total of 48 expansion tests was run. A detailed description of the app. and methods used in this invest., as well as a summary of available data obtained by previous investigators of this property of fused silica are given. A critical temp. or min. length was found at about −80°C. On htg. above or cooling below this temp., fused silica showed an expansion. A slight difference in the coeff. of expansion of transparent and non-transparent samples was noted. In nearly every case htg. to 1000°C and cooling to room temp. resulted in the indication of a very small increase in length. Typical expansion curves are shown and discussed. The authors' av. expansion curve of fused silica is compared with the results obtained by various other investigators. Several tables give av. coeff. of expansion for various temp. ranges. E. J. V.

Facts should govern the bottle industry. W. H. BOSHART. *Ceramist*, **8** [2], 101–106(1926).—The bottle-making mach. has brought about a complete revolution in the indus. The uniformity of the bottles now produced and their relatively low price, in spite of the present high cost of raw mats., have brought about an immense increase in their use. The great development has brought new and pronounced problems, one of which is a pronounced over-capacity for bottle-making, due to prohibition and more continuous operation of the factories rather than an increase in the number of plants. B. discusses betterment of organization and the need to consider present conditions when planning operations. B. considers the activities of the Glass Container Assn. to be an indispensible aid, particularly the reports of the Statistical Comm. The item of freight on the inbound fuel and raw mats. plus the freight on the container from the factory to the customer is larger than any other item of expense. B. lauds the work of the Traffic Dept. of the Assn. A good demand for glass containers in the immediate future is predicted. B. discusses the foreign and domestic situations that have a bearing on this factor. A. E. R. W.

Society of Glass Technology. ANON. *Chem. News*, **133,** 11–12 (1926); *Chem. Age*, **14,** 500 (1926).—Report of meeting on June 1 and 2, 1926. The use of glass in early ages is discussed. A rept. on the examn. of opal and opalescent glasses by the X-ray method showed that the opacity of fluoride glasses was due to sepn. of calcium or sodium fluorides, or mixts. of both. Expts. on the elec. condy. of glasses at temps. above their s. p. showed that the substitution of silica bysoda in a simple silica-soda glass increased the condy. Substitution of magnesia for silica increased the condy. slightly, while the substitution of alumina for soda or silica decreased the condy. The relation of viscosity to condy. was also considered. In a glass batch mixt., the presence of from 3 to 4% of moisture was reported as having a negligible effect on the ultimate compn. of the glass. E. E. P.

Recuperative glass melting. PRINZ. *Sprechsaal*, **59,** 235–37 (1926).—A fur. for mtg. glass by the recuperative process is described and illusd. by drawing. H. G. S.

Note regarding the use of arsenic for opacifying alkali-lime-silicate glasses with or without alumina. L. RIEDEL. *Sprechsaal*, **59,** 237 (1926).—R. found that with the glasses which he investigated, those contg. 12.24% Al_2O_3 were not opacified with Ar, while those free from Al_2O_3 were. H. G. S.

Optical glass manufacture. ANON. *Nature*, **117,** 211 (1926).—Interesting biog. details of Pierre Louis Guinand (1748–1824), who played an important rôle in the development of the art of making optical glass, are given by Paul Ditisheim in the *Bull. de la Société Astronomique de France*, April, 1925. The methods he adopted, after prolonged and laborious invests. are still considered essential in the present day manuf. of optical glass. In about 8 yrs. in a factory near Münich, he produced glass for more than 5,000 achromatic objectives. O. P. R. O.

Flexible glass 5,000 years ago. ANON. *Nature*, **117,** 791 and 834 (1926).—"Glass in the Old World" is title of a book published by M. A. Wallace-Dunlop in 1883 in which is given alleged opening of the first and second pyramids of Gizeh. These pyramids are known with tolerable certainty to have been built between 3969 and 3845 B.C.; the conclusion is that things found in them when first opened must have been made at least 5,000 years ago. The glass might be bended but not broken. In an address given by Sir Flinders-Petrie at University College, London, he refers to the use of glass by ancients for the purpose of weights. Three glass weights of the same denomination which had been found, proved on testing, to agree within $\frac{1}{200}$ of a grain. O. P. R. O.

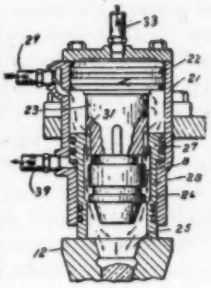
PATENTS

Method of molding glass and apparatus therefor. P. R. MURDOCK. U. S. 1,589-654, June 22, 1926. In a device of the character described, a mold comprising a lower casing having a fluid chamber, an upper casing having a fluid chamber, one of said casings being provided with cavities in its face, means for creating a difference in press. in said chambers, and means for communicating the press. difference to opposite sides of a sheet of glass arranged between said casings.

Apparatus and process for making sheet glass. FREDERICK GELSTHARP. U. S. 1,590,819, June 29, 1926. In app. for the manuf. of sheet glass, the combination with a tank or receptacle provided with an outlet, so as to permit the discharge therethrough of molten glass under the head press. of the tank, a stationary spreading table in position to receive the molten glass from said outlet of a width much greater than that of said outlet, a sizing roll over the table intermediate the ends thereof, a pair of traction rolls in advance of the sizing roll for engaging the upper and lower sides of the sheet and pulling it over the surface of the table and beneath the sizing roll, and a leer in advance of said traction rolls provided with means for carrying the glass therethrough.

Apparatus for making sheet glass. FREDERICK GELSTHARP. U. S. 1,590,820, June 29, 1926. In app. for the manuf. of sheet glass, the combination with a tank or receptacle provided with an outlet so as to permit the discharge therethrough of molten glass under the head press. in the tank, a stationary spreading table in position to receive the molten glass from said outlet of a width much greater than that of said outlet, a pair of sizing rolls at the forward end of the table of a length greater than the width of said outlet, and a leer in advance of said rolls.

Glass-forming machine. A. N. CRAMER. U. S. 1,590,423, June 29, 1926. In a glass blowing mach., the combination of a blank mold open at its upper end to receive a charge of glass, a blowing head movable into engagement with the mold, a piston in said head, and a mold capacity reducing element carried by said piston and movable thereby into the mold.

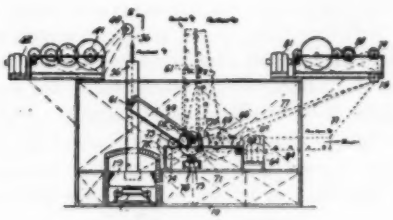


Refractory block used in building metallurgical furnaces. L. S. LONGENECKER. U. S. 1,590,303, June 29, 1926. A fur. roof composed of refrac. blocks arranged side by side and held together mainly by press. between their engaging surfaces, said blocks being inter-connected by means of tongues and grooves extending in a generally vertical direction, the said tongues and grooves being narrower at one end than at the other, and thereby operg. to prevent broken fragments of said blocks from falling away from said roof.

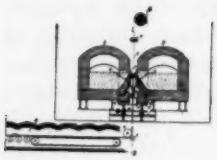
Glass-working machinery. ROY D. MAILEY AND WILFORD J. WINNINGHOFF. U. S. 1,591,175, July 6, 1926. In app. for joining tubular glass, in combination, means for heating the glass at and near the points of jointure, means for varying the amt. of heat emitted from said htg. means, and means for varying the press. of the atm. within the joined parts.

Process of and apparatus for making sheet glass and other articles. H. A. MYERS. U. S. 1,591,179, July 6, 1926. In app. for making sheet glass, the combination of means for supplying the molten glass, means for drawing a sheet from the mass of molten glass, means for deflecting the direction of travel of the sheet from a vertical plane to a horizontal plane, a shoe over which the glass travels from one plane to the other and means for interposing a preheated fluid between the glass and the surface of said shoe, thereby to prevent the sheet of soft glass from dragging on the shoe, thus avoiding injury to the surface of the glass.

Glass-making machine. A. A. ICENHOUR. U. S. 1,591,831, July 6, 1926. In a glass mach., a bait, means to lift the same to draw a sheet of glass, and a swingable support having asbestos covered rollers to receive the sheet and position it for entrance to the leer, substantially as set forth.



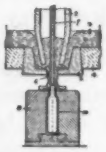
Apparatus for making wire glass. WALTER COX AND ARNO SHUMAN. U. S. 1,592,180, July 13, 1926. App. for making wire glass comprising the combination of a glass tank fur., confronting dams over which confluent streams of glass



flow from the tank, means for pivotally adjusting the dams to regulate the confluence of the flow, and devices for passing wire netting between the dams and through the confluence of the streams, substantially as described.

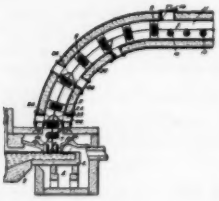
Process for making corrugated wire glass. ARNO SHUMAN. U. S. 1,592,228, July 13, 1926. The process of making wire glass which consists in rolling a plain sheet of glass with wire mesh embedded therein, and, while the interior portion of the sheet is sufficiently plastic by heat to permit twists of the mesh to stretch and while the exterior of sheet is sufficiently solid by cooling upon bending to retain its form, simultaneously corrugating said sheet and mesh in part by laying it upon a corrugated table and in part by pressing it between corrugated surfaces.

Method and apparatus for making blown glassware. G. E. HOWARD. U. S. 1,592,299, July 13, 1926. The method of making blown glassware that comprises causing a mass of molten glass to issue in a suspended mass from a downwardly opening discharge orifice, directing fluid under press. through the said orifice into the interior of the said mass while the said mass is still attached to the parent body, and simultaneously applying an elongating impulse to the said mass from above, thereby assisting in forcing the glass through the said orifice.



Glass-melting container. JAMES BRYCE. U. S. 1,592,336, July 13, 1926. A container or receptacle in which to fuse the ingredients entering into a glass batch, which container is formed from a ferrous alloy contg. a percentage of chromium such that oxidation of the surfaces of the container in contact with the ingredients during and after fusion thereof will be negligible.

Process of treating glass and the product thereof. C. A. KRAUS. U. S. 1,592,429, July 13, 1926. The process of treating glass, characterized by substitution in a delimited region in glass, for ions normally present in the glass, of ions of different atomic number, in quantity so restricted as to be normally invisible, but in quantity sufficient to be developable to visibility by differential condensation of liquid upon the glass.



Drawing sheet glass. J. P. CROWLEY. U. S. 1,592,444, July 13, 1926. In the art of producing sheet glass, the process of drawing the sheet from its molten source in a vertical direction until substantially set, and then bending the sheet into another plane along an arc of such curvature that the bending strains will not exceed the elastic limit of the sheet. App. for making sheet glass, comprising a receptacle contg. a pool of molten glass, and means for drawing a continuous sheet of glass vertically therefrom and carrying the sheet into another plane, comprising means for drawing the sheet vertically from the pool until set in flat sheet form, and means for gradually bending the flat sheet against its own elasticity into another plane.

Fused silica. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 240,489, Sept. 27, 1924. Cryst. SiO_2 is fused and then compressed to eliminate bubbles. N under press. of 2000 lbs. per sq. in. may be used for the compression, preceded by subjection to a vacuum. An app. is described. (*C. A.*)

Heavy Clay Products

A phenomenal case of tile breakage. R. A. HART. *Jour. Amer. Ceram. Soc.*, 9 [7], 474–76 (1926).—In 1921 an interesting case of tile breakage was discovered at

Hinckley, Utah, in a drain which had been laid for 3 years, the backfill ranging from 2 to 6 ft. The breakage was inversely propl. to the depth of the backfill and the tile had broken upward, all conditions of fracture being reversed. Some of the tile did not break until a portion of the backfill was removed. Invest. showed that the tile had been laid in a trench but slightly wider than the outside diam. of the tile, the mat. being a highly colloidal clay, extremely dry. The line was for relief of another drain and no water entered the line until the latter was tapped. Water percolating through the joints and saturating the adjacent clay caused an expansion which crushed the tile laterally. Subsequent lab. studies showed the clay to have a coeff. of expansion of 178.5.

The lime-sand brick industry. ANON. *Master Builder*, **769**, 68 (1926).—Setting up of Brit. stand. for lime-sand bricks dividing them into 3 qualities: engineering bricks, bricks for external walls, and bricks for internal walls, has established them as sound mat. for bldg. opern. in England. A history and brief description of the indus. are given. E. J. V.

Standard sized brick. ANON. *Manuf. in Can.*, **1** [6], 36 (1926).—The recognized stand. size adopted in Can., except in Ottawa, is $2\frac{1}{4}''$ x $3\frac{1}{4}''$ x 8″. Acceptance of this stand. in Toronto would be of great assistance to all in any way connected with the brick indus. E. J. V.

Imported brick must be marked. ANON. *Ceramist*, **8** [2], 73–74 (1926).—A commentary on the ruling issued by the customs division of the U. S. Treasury Dept. that imported brick in the future must have a definite marking indicating their point of origin. A. E. R. W.

Cleaning stony clays. ANON. *Brit. Clayworker* **34**, 341 (1926).—An Amer. machine or cleaning stony clay removes the larger stones by means of a reciprocating finger which travels backward and forward across rollers through which the clay passes, while the rollers grind the smaller stones to powder. H. G. S.

PATENT

Brick-making machine. H. R. MCCUNE. U. S. 1,591,045, July 6, 1926. In a brick making mach. in combination with a die for shaping a column of clay, surface ornamenting means, cutters for severing the column into units of brick and means for preliminarily smoothing edge portions of the surfaces to be ornamented and prior to such ornamentation, of finishing tools arranged on either side of the path of travel of the column of clay adapted to finish the smooth edge portions of adjacent ornamented surfaces after the ornamenting step and before severing the column into units of brick, adjustable and flexible supports for said tools for aligning the tools in relation to the travel of the column of clay and for self adjustment of the tools whereby the same may accommodate themselves to deflections or irregularities in the column of clay, and other finishing tools arranged on either side of the path of travel of the severed bricks adapted to finish the smooth edge portions of the corners of the ornamented sides of the brick units after the severance of said brick units from the column, and yieldable press. means for said last mentioned tools.

Refractories

The attack of arsenic compounds on fireclay refractory material. W. E. S. TURNER. (Discussion by D. J. MCSWINEY.) *Jour. Amer. Ceram. Soc.*, **9** [7], 412–17 (1926).—McSwiney's statement regarding arsenic compds. being responsible for rapid corrosive action on tank blocks is discussed. It is pointed out that if arsenic compds. exert a marked corrosive action on fire clay, it should be demonstrated by an increased iron-

oxide or alumina content, or both, in the resulting glass. Data collected in expts. run are presented which contradicts McSwiney's statement. Only when arsenic in excess of the amt. used ordinarily is present in glasses melted at temps. of 1450 and 1500°C, or above ordinary working temps., can corrosion due to arsenic be traced. A full discussion of corrosion of glass house refracs., effects of colors on the heat condy. of glasses at high and low temps., and variations between the types of glasses referred to in T's. paper and in McS's. is presented by McS. An abstract of this paper is given in *Nat. Glass Budget*, **42** [11], 7 (1926).

The mechanism of spalling. F. H. NORTON. *Jour. Amer. Ceram. Soc.*, **9** [7], 446–61 (1926).—A study has been made of the stresses and fractures developed in a solid when rapidly heated or cooled. The stresses were measured in bakelite specimens by the photoelastic method. High stresses in all cases were found to occur near the surface of the solids, but no high tension stresses were present when the specimens were being heated. A number of vitreous clay spheres and bricks were heated and cooled rapidly and the nature of the cracks was noted. In practically every case the fractures occurred as predicted from the measured stresses. Torque-deflection curves were obtained for a number of fire brick in torsion at different temps. The temp. at which plastic flow occurs for every mat. tested was approx. the same as the temp. of the initial deflection under compressive loads in a stand. load test.

Requirements of refractories for manufactured gas plants. S. S. COLE. *Jour. Amer. Ceram. Soc.*, **9** [7], 462–73 (1926).—The requirements of the refracs. used in gas producers, water-gas sets, horizontal retorts, vertical retorts, and gas and coke ovens are discussed with respect to the specifs. which the mat. must necessarily meet to prevent failure of the installations. Illustrations show various types of installations and details of certain refrac. shapes employed. The temps. encountered in various portions of the carbonizing chambers, flues, and regenerators give a fair idea as to the duty which the fire brick must meet in operation.

Some experiments on the development of sillimanite refractories for glassmaking. W. A. MCINTYRE. *Jour. Soc. Glass Tech.*, **9** [37], 73–80 (1926).—Tests of resist. to corrosion against glasses of widely different compns. of test bars and of small exptl. pots of sillimanite clay mixts. showed these mixts. to have a very much higher resist. than commercial clay refracs. tested under the same conditions. Test specimens contd. about 70% sillimanite. Best results were obtained by using fine-grained mixts. Ball clays require too high a percentage of sillimanite, so refrac. clays were used. Weathering of mixts. gave improved results. Pot fur. siege built of sillimanite clay mixt. gave excellent service. D. J. McS.

Behavior of carborundum under working conditions. F. G. JAEGER. *Bull. Amer. Ceram. Soc.*, **5** [7], 309–11 (1926).—J. shows how with proper use carborundum will give very fine service over a long period of time. Combustion gases are more severe in their action on silicon-carbide refrac. when trapped than when freely circulating. "Protected" brick showed deterioration and swelling where brick exposed to the heat were unharmed. It is advisable to guard against cracking the surface of a carbofrax muffle through mech. strains as there is a greater tendency for gas attack on the remaining refrac. body if this happens. E. J. V.

Vitrox: a new ceramic material said to strengthen pot clays. T. S. CURTIS. *Nat. Glass Budget*, **42** [8], 19 (1926).—A product manufd. by fur. treatment of cyanite has the outstanding characs. of imparting remarkable strength and toughness to clay bodies to which it is added. It is comparatively insol. in molten glass and increases the resist. to the corrosion of glass of pot clays it is added to. It is claimed its use will reduce warpage and control shrinkage. E. J. V.

Mullite content of some of our commercial blocks. FRED S. THOMPSON AND HOWARD I. VORMELKER. *Glass Ind.*, **7** [7], 165 (1926).—Methods and results of detn. of mullite content in commercial glasshouse refrac. are given. Reheating samples to 1450°C for 24 hrs. shows a very substantial increase in mullite content of the blocks. All attempts to reconcile mullite content with chem. compn. failed and length of service of the different makes of blocks did not appear propl. to the mullite content.

E. J. V.

Investigation of refractory brick. BRUNS SCHULZ. *Feuerfest*, **2** [4], 33 (1926).—Discusses work done by previous investigators covering refractoriness of clay mixt., classification and compn. of fire brick, especially for marine work; connection between anal., refractoriness, softening and m. p.; compn. of anthracite slag. F. A. W.

The use of refractory cements and plastic refractories. M. C. BOOZE. *Fuels and Fur.*, **4** [6], 677–78 (1926).—Users very often take great care to get the best refracs. and yet get inferior mortar for laying these refracs. It frequently happens also that when the best mortar mats. are procured, mats. such as lime, Port. cement, and salt, or sodium silicate are added to improve the troweling properties. Such additions are likely to decrease the refractoriness of the mortar and act as a corrosive agent upon the fireclay brick. Hence such a practice should not be followed except in cases where low temps. prevail in the fur. in which refracs. are used. If it is desired to improve troweling properties of mortar, it should be done by adding plastic fire clay or organic plastics such as dextrin or pitch. Where 2 different mortars are used in the same installation they are often differentiated by adding coloring matter to one of them. It is pointed out that the best grade of clays should be used in patching cupolas for if low grade clays are used a greater slagging action results. Plastic refracs. are now finding much general application. Among the most outstanding advantages of plastic refracs. are their value for quick repairs and for the replacement of certain special shapes.

R. M. K.

Open hearth steel furnace conditions as they affect refractories. F. W. SCHROEDER AND E. M. LARSEN. *Fuels and Fur.*, **4** [6], 705–706 (1926).—The conditions in a fur. must be well known before the proper refracs. can be selected. Service conditions which cause the failure of a refrac. body are usually classified as follows: (1) excessive temps.; (2) temp. fluctuation; (3) slag corrosion; (4) excessive load, and (5) abrasion. Any one of these conditions may cause failure but most failures are caused by a combination of 2 or more of these conditions. As to temp. it may be said that in slow-working open hearth furs. the max. roof and wall temps. vary from 2750 to 2800°F and in sharp-working furs. from 2900 to 2975°F. Temps. vary from 2900 to 1900°F. Slag corrosion is brought about by iron-oxide particles, dusts, and fume. Small quantities of lime, silica, magnesia, and manganese dioxide are also present in these dusts and fumes. Excessive arch stresses on localized areas caused by irregularity in brick shapes is a contributing factor in roof deterioration. Abrasion does not appear to be a very important factor in open hearth refrac. life. R. M. K.

Mullite refractories and their industrial application. M. L. FREED. *Fuels and Fur.*, **4** [6], 711 (1926).—Owing to the fact that a source of reasonably pure cyanite in large quantities has not been available and to the fact that cyanite shatters on htg., expts. with cyanite refracs. have not proceeded along practical lines. However, a deposit of cyanite 95% pure has recently been discovered in India and expts. have been carried on by the Bur. of Stand. looking to the development of methods for converting of cyanite into mullite by calcination and for making refracs. from mullite, either pure or mixed with bonding clay. The crude mineral was crushed and heated to 1450°C at which temp. it was converted into mullite. It was then crushed to various grain sizes and bricks were made by dry press process from the pure minerals or clay-mineral mixts.

Load tests; pure cyanite, 50 lbs. /sq. in. at 1450°C for 1.5 hours showed deformation of 1.77%; pure mullite, same condition as above except at 1500°C showed deformation of 2.85%. Pure cyanite and pure mullite brick remain rigid at cone 35. Pure mullite brick stood 29 quenchings (850°C to room temp. in water), pure cyanite 60 quenchings and a brick made from 75% mullite 25% ball clay or fireclay mixt. stood 73 quenchings. These refracs. also showed a uniform thermal expansion. See also *Ceram. Abs.*, **5** [7], 217 (1926). R. M. K.

Refractories for by-product coke ovens. MARTIN J. CONWAY. *Fuels and Fur.*, **4** [7], 784 (1926).—Coke ovens of the Becker type are constructed entirely of silica from the base of the regenerator to the top of the cross-over flues "as in addition to its efficient heat condy., silica resists the action of the salts which may be present in the coal." Special shapes are needed for this construction, careful attention being paid to grind and firing. R. M. K.

Selection of refractories for use in steel plants. M. C. BOOZE. *Fuels and Fur.*, **4** [7], 799–802 (1926).—The best method of selection is trial under service conditions. Care must be taken, however, to see that these trials are made under fair and representative service conditions. The phys. tests for refracs. are at best only approx. of actual fur. conditions and should be resorted to only when service trials can not be made. Standard tests may be used to eliminate the very unsatisfactory products. The tests usually applied are: (1) fusion or softening point, (2) chem. anal. (3) deformation under load, (4) spalling, (5) permanent contraction or expansion. The standard procedure for making these tests is described. Metallurgical processes are sometimes so complex and severe that no refrac. will withstand them. Hence metallurgical operations must sometimes be modified in accordance with the limitations of refracs. Steel manufacturers are chiefly concerned with refracs. for open-hearth furs., blast furs., heating furs., regenerators, and coke ovens. Requirements of the operations and limitations of refracs. must be considered together. In open-hearth furs., their size and high temps. employed require silica brick and the necessity for the bricks to remain rigid in the arch and resist the action of basic slag requires other refracs. such as magnesite and chrome. Clay refracs. are usually used in blast furs., stoves, regenerators, and htg. furs. Owing to the high temps. employed in coke ovens, and to severe abrasion, and the necessity for a small amt. of permanent expansion, hard-fired silica brick are required. The development of new refracs. and water and air-cooled walls promises much for the future. R. M. K.

Temperature measurement of refractories during a load test. W. MIEHR. *Tonind. Ztg.*, **50**, 563–67 (1926).—The softening temp. of the same refrac. varied from 1360 to 1403°C, depending upon the methods used for measuring the temp. H. G. S.

Calcining grog. ANON. *Tonind. Ztg.*, **50**, 572–73 (1926).—In a chamber continuous kiln having 20–24 chambers, 100 T. of grog can be calcined daily. Rotary kilns are impractical for this purpose since they tend to pulverize the clay and require constant repairing, which tends to make it more of a periodic rather than a continuous process. H. G. S.

Andalusite; a new refractory. ANON. *Brit. Clayworker*, **34**, 336 (1926).—Firebricks, glasshouse pots, saggers, and crucibles made from andalusite are constant in vol. when heated, have a high resist. to sudden changes in temp., will stand considerable press. at high temps. and have a refractoriness equal to cones 35–36. The mat. "works" well if a little pyrophyllite is added, and if a little clay is also added, it may be used in casting hollow ware. H. G. S.

Choice of refractories for boiler fire boxes. QU. B. ZIEMERT. *Brennstoff und Wärmewirtschaft*, **8**, 40–43, 124–27 (1926).—A discussion. (*C. A.*)

Magnesia crucibles in an arc furnace. E. E. MOORE AND A. HAYES. *Proc. Iowa Acad. Sci.*, **31**, 285 (1924).—An abs. Baker's "C. P. MgO" is decarbonated by htg. to 1200°F for 3 hrs., the CO_2 liberated being driven from the fur. by a slow current of air. The magnesia is next packed loosely in graphite containers and sintered in an arc fur. by htg. to 3100°F and holding at that temp. for 1 hr. The sintered magnesia is then ground to pass a 100-mesh sieve, shaped into the desired form in graphite containers by packing dry around a graphite core. The core is removed, graphite lids are placed on the containers and the sintering is repeated as above. The crucibles are of sufficient strength to allow pouring molten metal. (*C. A.*)

PATENTS

Manufacture of highly refractory oxides. T. R. HAGLUND. Swed. 60,425, Mar. 3, 1926. Mat. contg. the oxides are fused together with reducing agents and sulphidic mats. resulting in a fusion contg. sulphides as well as one or more highly refrac. oxides, for instance Al_2O_3, Cr_2O_3, MgO, ZrO_2. The resulting mass is treated with HCl or with Cl and HCl to convert the sulphides into chlorides. These are sepd. by evapn. or soln. (*C. A.*)

Terra Cotta

An attempt to secure a uniform mixture of fine and coarse particles in grog from a bin. W. A. HULL. *Jour. Amer. Ceram. Soc.*, **9** [7], 477–79 (1926).—A sloping chute or trough down which the stream of grog flows to the bottom of the bin, instead of dropping with a free fall places grog in bin in such a way that it comes out of the bin fairly well averaged as to sizing.

Grog for terra cotta. D. F. ALBERY. *Bull. Amer. Ceram. Soc.*, **5** [7], 316–19 (1926).—The diminishing of supply and sources of grog are discussed. Advantages of the use of manufd. grog and suggested methods for making it are enumerated. Recognition of the importance of the question is the intention of A.'s plea. E. J. V.

Urge use of chemical stoneware. ANON. *Amer. Glass Rev.*, **45** [39], 26 (1926).—A brief résumé of the manuf. of chem. stoneware. Its use to replace lead or metal containers is urged. Methods of testing glassware are also mentioned in this report of addresses given at Cleveland during the Chem. Equipment and Process Engineering Exposition, May 13, 1926. E. J. V.

White Wares

The use of Georgia and North Carolina kaolins in a semiporcelain body. S. E. HEMSTEGER AND W. C. STIEF. *Jour. Amer. Ceram. Soc.*, **9** [7], 444–45 (1926).—Tables are given, comparing properties and anal. of Ga. and N. Car. kaolins and 2 English china clays. These 2 domestic clays are found to be very adaptable to this type of body. N. Car. kaolin reduced warping of ware in the glost kiln, but made the body less plastic. Ga. kaolin enabled a higher flint content to be used; also imparted greater dry strength to the body. Since using these domestic kaolins, crazing has been reduced.

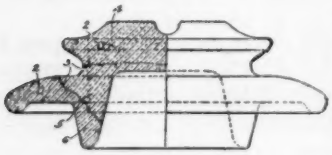
White ware. H. HARKORT. (Trans. by W. L. SHEARER AND A. W. HOLZMANN.) *Ceramist*, **8** [2], 75–85 (1926).—White ware technology is of more recent origin than porcelain technology. White ware represents an improvement over faience and has certain advantages where porcelain unquestionably has disadvantages. It was the result of replacing the colored firing clay of the faience body by a white or almost white firing clay, and replacing the opaque glaze by a cheaper transparent glaze. The manuf. of such products requires 2 firings; the 1st firing serves to give the ware strength, while in the second the glaze is melted on, usually at a comparatively low temp. The outstanding charac. of this type of ware is the high degree of brilliancy and luster made possible by the use of underglaze colors. The av. whiteware body contains 45 to 55 %

of clay substance, 35 to 45% of sand or quartz and 5 to 10% of feldspar or chalk. The clay substance is introduced in part as a fat earthenware clay firing white in a correct batch, in part as kaolin. After discussing different body compns. H. makes a comparison of English and German earthenware bodies, and discusses methods of classifying them. H. then commences a discussion of the different sorts of finished products going into the details of the prepn., washing, shaping, and casting of general ware. (To be continued.) A. E. R. W.

Preparation of ceramic bodies by the continuous process. M. DORST. *Sprechsaal*, **59**, 233–34 (1926). H. G S.

PATENT

Process of preparing material for ceramic articles. A. O. AUSTIN. U. S. 1,589,617, June 22, 1926. The process for prepg. mat. for ceram. articles, wherein the ingredients are powdered and lawned dry, after which sufficient water is added to produce a mix suitable for forming, which mix is permitted to stand in a closed chamber having the press. therein reduced below atmospheric for a sufficient length of time to permit the water to thoroughly permeate the mass.

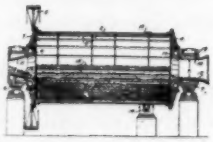


Method of testing insulators. ALBERT VAUPEL. U. S. 1,590,457, June 29, 1926. The method of testing insulators which comprises cutting and sepg. portions of substantially finally formed insulating bodies to permit inspection of the interior structures thereof, applying a coating of a hardening liquid to one of the adjacent cut surfaces of, and then placing together, the sepd. parts of those passing inspection prior to hardening.

Equipment and Apparatus

PATENT

Rod mill. ROY C. GREENFIELD. U. S. 1,591,703, July 6, 1926. In combination, a rotary casing and feed and discharge end heads co-acting therewith to form a comminuting chamber, said casing being free from manhole openings, a plurality of freely tumbling rods within and extending substantially the entire length of said chamber, and a supporting trunnion for the mill associated with said discharge end head, said discharge end head having a central manhole opening through said trunnion of sufficient size to permit free transfer of rods therethrough, said opening being of less diam. than ½ of the diam. of said chamber at said head but greater than 14 inches and the space in line with said opening being unobstructed throughout the length of the mill.



Kilns, Furnaces, Fuels, and Combustion

Comparison of gas and electricity for industrial heating. R. C. GOSREAU. *Chem. Met. Eng.*, **33**, 337–40 (1926).—The utilization percentage, (heat used to heat developed), varies greatly. Since heat input to the work is related to fur. vol. this sets a limit on the latter. The cheapest method of gas heating is by direct impingement of the flame on the work. The most costly is the muffle fur. In another type the hot waste gases are carried along the fur. roof at a low velocity, the roof being well-insulated. These gases radiate heat downward to the work, and are passed through a recuperator outside the fur. There are 3 methods of elec. htg., (1) by direct or radiated arc, (2) by direct

or radiated resist. (3) and by high frequency induction. Direct resist. htg. is only successful on pieces of simple shape. Radiated resist. has nearly universal application for temps. up to 2000°F. Such fur. should have high rates of energy input, with the focus of radiation in the work. The ratio of fur. vol. to work vol. can be near unity. The choice of a htg. system finally rests on the relative gas and elec. rates, the utilization percentage of the installations, and the quality of the product. M. E. M.

Kilns for the firing of silica and clay fire brick. W. GRUM-GRJIMAJLO. *Feuerfest*, **2** [4], 35 (1926).—Description and plans of chamber kiln designed in accordance with certain hydraulic theories advanced by G. F. A. W.

Errors in firing continuous kilns. ANON. *Master Builder*, **769**, 62 (1926).—Various errors which cause difficulties in the opern. of continuous kilns are enumerated. These include (1) water in the foundations, (2) too small a chimney or flues, (3) kiln being too short, preventing sufficient use being made of the heat in the kiln gases, (4) setting damp goods, and (5) supplying too little air to the kiln. E. J. V.

Rotary driers. ANON. *Master Builder*, **769**, 63 (1926).—Rotary driers are the most efficient devices for drying raw clay, sand, chalk, and many other mats. if their opern. is understood. Difficulties experienced are (1) smaller output than anticipated due to too small a drier being ordered, faulty design, or bad management, (2) remoistening of mat. just before leaving the drier due to the gases being too cool to carry all the moisture they contain, and (3) dust created by the grinding action exerted on the mat. Drying is facilitated if the mat. is supplied in pieces small enough to be broken up readily in passing through the drier. E. J. V.

Kiln capacity and output. ANON. *Master Builder*, **769**, 68 (1926).—Low output in a continuous kiln with large capacity may be due to too short a kiln, or damp bricks in the kiln, necessitating a great radiation loss caused by a slow traveling fire. Making the kiln long enough to permit gentle heating and cooling at a suitable rate, and setting with only dry brick will remedy the low output. E. J. V.

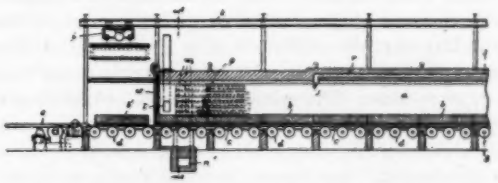
Recent developments in fuel technology. R. WIGGINTON. *Fuel in Science & Practice* **5**, 135–37 (1926).—Brief rev. (*C. A.*)

BOOK

Taschenbuch für Feuerungstechniker. FR. FISCHER. (Compiled by Fr. Hartner.) ALFRED KRÖNER. Leipzig, 1925. Price 9 GM. *Archiv. Wärmewirtschaft*, **7** [6], 180 (1926).—Contains data on heat theory, fuels, and technique of firing.

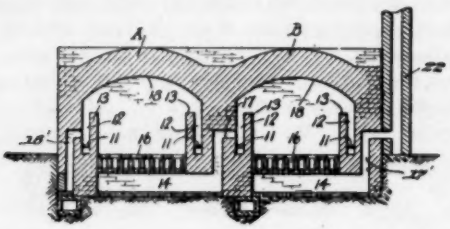
PATENTS

Tunnel kiln. A. MCD. DUCKHAM. U. S. 1,590,154, June 22, 1926. A straight muffle fur. or kiln comprising a htg. section having enclosing walls sepg. it from the htg. gases, the walls of the htg. section having multiple htg. fires isolated from one another throughout their length, and means for connecting said htg. flues in alternative parallel arrangements with a source of htg. gases.

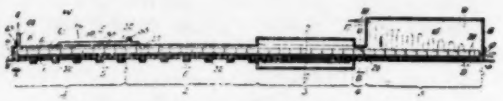


Kiln. HENRY FREEBOROUGH. U. S. 1,590,935, June 29, 1926. A plurality of kilns arranged side by side and forming a unitary structure, a fire box extending longitudinally of each kiln and adjacent each side thereof, doors on the sides of the structure to permit of access to said fire boxes, one wall of each box terminating in spaced relation with the top of the kiln, a floor for each kiln having openings therein, channel-like members extending across each kiln adjacent the ends thereof, and communicating with the

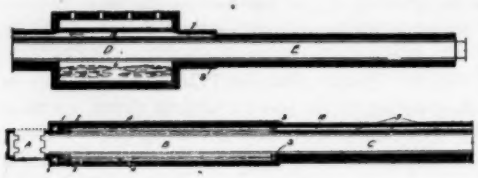
space beneath said floor, passages establishing communication between the said channel-like members of one kiln and the fire box of the adjacent kiln, an additional channel-like member arranged between the first-mentioned members and equidistantly spaced therefrom, and also communicating with the space beneath said floor, a tunnel establishing communication between the last-mentioned member and the atm., and a door closing the outer end of each tunnel for the purpose specified.



Tunnel kiln. W. E. WILSON AND H. G. LYKKEN. U. S. 1,590,462, June 29, 1926. A kiln comprising a cooling section having a ware passage and a convection space above the passage.



Tunnel kiln. WILLIAM E. WILSON AND HENRY G. LYKKEN. U. S. 1,591,599, July 6, 1926. A tunnel kiln, comprising a series of chambers including a firing chamber and drying chamber, a radiator in the drying chamber, means conducting hot gases from the firing chamber into the radiator, means withdrawing the gases from the radiator and discharging a portion thereof into the interior of the drying chamber.



Calcium carbide, ferrosilicon, etc. GEB., SIEMENS & CO. Brit. 240,131, Sept. 19, 1924. In producing CaC_2, ferro-Si, and substances similarly prepd. in an elec. furnace, the mats. treated act as resistances and the electrodes, which are fixed or stationary, are protected by a mass of granular C or other non-fusible mat. Various mech. details are also specified. (*C. A.*)

Geology

High grade clays of the southeastern states. W. M. WEIGEL. *Ceramist*, **8** [2], 86–100 (1926).—W. outlines the development of the kaolin and white clay indus. of the southern states up to 1924 when they produced 291,000 T. valued at $2,785,000, which was 71% of the total production of high-grade clays in the U.S.A. W. gives a classification of clays based on their phys. properties. The location and description of the clay deposits of Va., N. Car., S. Car., Ga., Fla., Ala., Miss., and Tenn.-Ky., are given in about 7 pages. W. states that in many cases the reserves of sedimentary clays are enormous. The mining and prepn. of residual kaolin and sedimentary clays in the different districts is described. The utilization of the types of clays occurring in the different states is discussed and the claim that domestic clays are inferior to the imported clays denied. Conditions favorable to the establishment of ceram. indus. in the South are pointed out, including the great opportunity for building up an export trade with S. Amer. A. E. R. W.

Beryllium from Canada. ANON. *Chem. Age*, **14**, 539 (1926).—A rich deposit of beryl, the aluminum silicate of beryllium, is reported in Renfrew County, Ont., 150 miles northeast of Toronto, and near the village of Quadville. Attention is given to

beryl as a source of the metal beryllium (or glucinum). It is also used to replace feldspar in the higher grades of porcelain spark plugs and insulators. E. E. P.

Magnesite in Canada. ANON. *Master Builder*, **769**, 35 (1926).—The Natl. Research Assn. of Canada is investigating the utilization of magnesite with a view to (1) enabling as large a portion of the rock as possible to be used; (2) converting it into such forms as will conform to the strictest specif.; and (3) to find new uses for it. E. J. V.

Georgia clays for brick making. ANON. *Nat. Glass Budget*, **42** [6], 17 (1926).—Properties of fire brick made of Ga. clays are compared with those of stand. refrac. E. J. V.

Age of minerals and rocks. ANON. *Nat. Glass Budget*, **42** [7], 17 (1926).—A new method of detg. the age of minerals and rocks by their content of lead and helium is being studied in the chem. lab. of the Geol. Surv. E. J. V.

Silica. R. B. LADOO. *Nat. Glass Budget*, **42** [7], 26 (1926).—Different forms in which silica exists are listed. Methods of prepn. of silica for market and various specif. of different indus. are mentioned. E. J. V.

Glass sand is making Ottawa, Illinois, famous. L. B. COLBY. *Nat. Glass Budget*, **42** [8], 23 (1926).—The geology of LaSalle County in which Ottawa, Ill., is located, is summarized. E. J. V.

Mineral production. (India.) ANON. Records of the Geol. Survey of India, **57**.—Quinquennial rev. of the mineral production of India for the years 1919 to 1923. O. P. R. O.

China clay. (India.) ANON. *Chem. Trade Jour. and Chem. Eng.*, **78**, 702 (1926). —The exploitation of china clay resources of Behar is under consideration. O. P. R. O.

Bauxite. Gwalior, (India). S. M. MEHTA. Gwalior Govt. Dept. of Mines. 1925.—General description of laterite and bauxite deposits of Gwalior. Mineral ser. No. 18. 23 pp. O. P. R. O.

Chemistry and Physics

A method for the determination of the relative surface areas of powdered materials. W. A. KOEHLER. *Jour. Amer. Ceram. Soc.*, **9** [7], 437–43 (1926).—The ratios of the surfaces of powders of different degrees of fineness are obtd. by detg. the rel. amts. of a radioactive substance, ThB, adsorbed on the surfaces of the powders. The ThB is dissolved in an ammoniacal soln. of water or alcohol, and equal-wt. samples of the various powders are placed in equal vols. of this radioactive soln. After adsorption equilibrium is complete, 10 cc. of the clear supernatant liquid of each sample are evaporated to dryness on watch glasses, and the relative radioactivities of the deposits are measured in an electroscope. Since, for a given concn. of radioactive soln., the degree of adsorption is not a straight-line function of the surface exposed, an adsorption curve must be detd. for each mat. studied.

The origin of the charge on colloidal particles. HENRY BOWEN OAKLEY. *Jour. Phys. Chem.*, **30** [7], 902–16 (1926).—The charge of a colloidal particle is explained by the ionization of the mols. on its surface. According to the theory, the positive charge on a ferric hydroxide sol contg. a small quantity of HCl, is due to dissociation of positively charged iron-ions and negative chlorine and possibly hydroxyl ions. The iron-ions are held to the particles as a part of a mol. aggregate of ferric hydroxide, while the chlorine-ions are in soln., but, because of strong electrostatic attraction by the positive-ions on the surface, may not diffuse far from the particle unless there are other negative-ions to replace them. The negative charge of a silicic acid sol contg. a small quantity of sodium hydroxide is similarly explained. The Donnan equilibrium is explained, and applied to surface ionization theory. The theory is considered in relation to the coagu-

lation of silicic acid by calcium salts, and the elec. double layer of colloids. A given suspensoid should be coagulated by different acids at those concns. at which their hydrogen-ion concns. are the same, which has been proven for clay by Bradfield.

E. E. P.

Aqueous solutions of sodium silicates. Part III. Sodium-ion activity. R. W. HARMAN. *Jour. Phys. Chem.*, **30** [7], 917–24 (1926).—The true ion concns. in solns. of sodium silicates are not shown by vapor press. and freezing point measurements, nor by measurement of the extent of hydrolysis; due probably to complex ionic aggregates, which are indicated by condy. and transport number expts. If ionic aggregates are formed, the sodium-ions should equal the sum of the silicate and hydroxyl-ions and the sum of the three ions equal the total ion concn. The sodium-ion activity may be measured by the sodium-amalgam electrode devised by G. N. Lewis. The exptl. methods used are described, and the calcn. of results shown. The report is summarized as follows: (1) Measurements of sodium-ion activity have been made for ratios 1 : 1, 1 : 2, 1 : 3, and 1 : 4, at concns. ranging from 1.0–0.01N. (2) The activity coeff., γ, has been plotted against the wt. normality, N_w, and against the ratio $Na_2 : SiO_2$. (3) The curve, γ, against N_w for ratio 1 : 1 passes through a min. at a concn. lying between 0.1–0.2 N_w. The other curves show no min. (4) In very dilute soln., γ is high, but not so high as in corresponding concns. of NaOH, whereas in concentrated solns. of higher ratios γ is abnormally low. The general conclusion is that both the increase of concn. for any given ratio, and the increase of ratio for any given concn., very markedly reduce the activity of the sodium-ion. E. E. P.

Titanium. CYRIL S. FOX. *Trans. Min. and Geological Inst. of India*, **20**, 216 (1926). —Notes on titanium, zirconium, cerium, and thorium. Titanium and titanium-bearing minerals are discussed; special attention is directed to the most important Ti minerals of commercial importance, (ilmenite and rutile) with world's production of these ores. Uses of titanium are given Titanium dioxide (pure rutile) has been used for producing a fine honey-yellow underglaze on pottery and also in the prepn. of an ivory white enamel for artificial teeth. Another important use is the prepn. of pigments and paints. The process for manuf. of composite pigments is broadly: Ilmenite is smelted in an elec. fur. with certain fluxes, whereby a Ti concentrate is produced which is afterwards dissolved in sulphuric acid. This forms a soln. of Ti sulphate comparatively free from iron, most of the iron having been eliminated from the concentrate in the smelting process. The Ti sulphate soln. is mixed with blanc fixe and the mass boiled by indirect steam, thereby pptg. Ti hydrates upon a base of blanc fixe. By subsequent calcination, the amorphous ppt. is converted into the crypto-crystalline or micro-crystalline state. Important papers on Ti pigments have been presented at the Paint & Varnish Soc., 1921, by Washburn and McGougan, and at Royal Soc. of Arts, 1922, by Noel Heaton. H.'s remarks are full of enthusiasm for the new white pigments. Composite pigments, consisting chiefly of titanium dioxide, 25 % and barium sulphate 75 % are commercially known as titanium white, to distinguish them from the pure titanium dioxide. Commercial titanium white is normally (Norwegian) made in two strengths. One "standard," consisting of 26.5 % TiO_2 and 73.5 % $BaSO_4$, while the other, "extra," consists of much lower proportions of barium sulphate. Paints made with these pigments are not prone to crack, have stood the weather test well, are stable against light, do not discolor by fumes and gases, and are non-poisonous. The deposits of monazite sand on the Travancore coast are the best known deposits in India but concns. of ilmenite in the river sands may still be discovered in workable quantities both in Upper Burma and the Indian Peninsula. Successful expts. have been carried out and the question of commercial production of pure titanium dioxide from Travancore ilmenite is under consideration; supply is almost inexhaustible as the beach sand contains 70 % of this mineral.

Norway possesses the best known workable deposits of Ti ore. Russia is known to possess rich occurrences. Canada's valuable Ti deposits are discussed; also the deposits of the U. S., Brazil, Africa, Australia, New Zealand, and Ceylon. O. P. R. O.

The valuation of nitrates. ANON. *Glass Ind.*, **7** [7], 164–65 (1926).—Various deposits of alkali nitrates are described. Their use in the glass indus. is discussed. Methods of anal. of the nitrates are outlined. E. J. V.

The celestite from S. Gaudenzio, Senegal. E. ONORATO. *Atti accad. Lincei*, **33**, ii, 508–12 (1924); *Chem. Zentr.*, **1925**, I, 2158.—Crystallographic measurements of a celestite contg. 54.01 SrO, 0.74 BaO, 0.83 CaO, and 43.02% SO_3 are given. (*C. A.*)

Observations on the analysis of silicates. O. CANTONI. *Ann. chim. applicata*, **16**, 92–95 (1926).—*Evapn. of SiO_2.*—In the SiO_2 detn. the addition of NaCl is recommended to increase the surface of solid during evapn. so that prolonged htg. is unnecessary. For filtering $Fe(OH)_3$, $Al(OH)_3$, etc., the addition of kaolin is recommended, with correction for its loss in wt. upon ignition. For fusion of the ignited Fe_2O_3- Al_2O_3 ppt., at least 20 times as much $KHSO_4$ should be used. The simplified method for detg. alkalis (*C. A.* **19**, 3442) is very satisfactory. (*C. A.*)

PATENTS

Process of treating boron-containing minerals. ANDREW KELLY. U. S. 1,590,099, June 22, 1926. The production of an alkali-metal pentaborate by first treating in soln. a quantity of boron-contg. min. with a sol. non-alkali-forming metal sulphate, then converting said treated mineral into alkali-metal pentaborate by adding to said soln. a further quantity of said boron-contg. min., and thereafter crystallizing out said alkali-metal pentaborate.

Manufacture of titanic and zinc compounds. PIERRE PIPEREAUT AND ANDRÉ HELBRONNER. U. S. 1,590,697, June 29, 1926. A process for mfg. white pigments by a dry process, wherein dry titanic sulphide obtd. in a known manner from ilmenite is mixed with dry $ZnSO_4$, the mixt. being heated to red heat and calcinated within a closed oven.

Process of producing alumina, alkali, and dicalcium silicate. ALFRED H. COWLES. U. S. 1,591,364, July 6, 1926. The process of obtg. soda aluminate from substances contg. soda, lime, alumina and silica, which consists in forming a sintered product contg. ingredients in the mol. ratio of one of silica to two of lime, more than one and substantially less than 1.76 mols. of soda to one of alumina, and subjecting the sintered product to a leaching process, substantially as described.

Process of producing alumina, alkali, and dicalcium silicate. ALFRED H. COWLES. U. S. 1,591,365, July 6, 1926. The process of sepg. alumina from compds. contg. it, which consists in htg. to a sintering temp. a mixt. contg. combined alumina and silica, calcium carbonate and sodium carbonate in such propns. that the furnaced product shall contain 1 mol. wt. of silica to substantially 2 mol. weights of calcium oxide, and 1 mol. weight of alumina to substantially 1 mol. wt. of sodium oxide, dissolving from the resultant mixt. sodium aluminate, employing as a solvent water initially contg. sodium oxide so that the resultant soln. shall contain materially less than 1.75 and more than 1.1 mols. of sodium oxide to 1 of alumina, and sepg. the alumina by known means.

Manufacture of plastic material out of non-plastic oxides. OTTO RUFF. U. S. 1,591,563, July 6, 1926. A process of making plastic mat. which comprises mfg. finely divided oxides by the htg. of salts which liberate the oxides without fusion of the latter, and without sintering of the latter to a temp. capable of producing the oxides in a non-fused and non-sintered state, and subsequently htg. the same with water and an electrolyte capable of imparting plasticity so as to convert the oxides into a plastic condition, without a long grinding operation.

Process of making arsenates of manganese. W. L. TANNER. U. S. 1,591,795, July 6, 1926. Process of making manganese arsenates which comprises htg. to reacting temp. a mixt. of a compd. of manganese capable of oxidizing arsenious oxid with arsenious oxid in the presence of water.

Process of treating alunite. GEORGE S. TILLEY. U. S. 1,591,798, July 6, 1926. In the treatment of alunite, the herein-described process which comprises digesting alunite with hot dilute sulphuric acid, of such strength and in such amount as to dissolve practically the whole of the iron and potassium present, and to leave a residue of alumina-contg. mat. which is sol. in hot sulphuric acid.

Process of producing arsenate of lime. FLORENTIN BIDAUD. U. S. 1,591,958, July 13, 1926. A process of producing calcium arsenate in a continuous way, which consists in charging in a continuous way calcium arsenite into a fur., heating a part of the starting charge to the oxidizing temp., discontinuing the htg. as soon as the reaction commences and causing a current of oxidizing gases to pass through the progressing mass, and regulating the temp. to an amt. necessary and sufficient for a complete oxidation.

Process of extracting potassium and phosphorus from rocks. JOSEPH F. CULLEN AND THOMAS E. HARPER. U. S. 1,592,757, July 13, 1926. The process of extracting potassium and phosphorus from potassium bearing and phosphorus bearing rocks which consists in volatilizing the potassium and the phosphorus compds. by smelting of the rocks under reducing conditions and thereafter recovering the potassium and the phosphorus compds. from the gases produced by the smelting operation.

Composition from boron and carbon. E. PODSZUS. U. S. 1,585,412, May 18. A quantity of C greater than that contained in B_6C is dissolved uniformly in a molten mixt. of B and C or B carbide. The product has approx. the hardness of the diamond. W may replace some of the B. (*C. A.*)

General

The development of definitions for ceramic terms. A. S. WATTS. *Bull. Amer. Ceram. Soc.*, **5** [7], 305–308 (1926).—W. points out that if the purpose of developing definitions is to aid in standardizing ceram. processes, they should be framed to protect the terms from abuse. Another consideration is the special field of science in which the term is to be used. All definitions approved by the AMER. CERAM. SOC. should be indicated as applicable only to the field of ceram. Discrepancies in true and popular definitions of several words are pointed out. Problems causing delay in the presentation of definitions are listed and constructive criticism is solicited. E. J. V.

Boilers and boiler room accessories.—V. M. E. D. *Manuf. in Can.*, **1** [6], 12–13 (1926).—Three types of steam traps—float traps, expansion traps, and bucket traps are discussed, and advantages and disadvantages of each enumerated. Superheaters are also discussed, as to function, type, and mat. used in making them. E. J. V.

New course in ceramic engineering. ANON. *Pottery, Glass & Brass Salesman*, **33** [24], 27 (1926).—Announcement of a course in ceram. engineering to be opened next fall at the School of Mines and Metallurgy at Rolla, Mo., with M. E. Holmes as head of the dept. is made. E. J. V.

Linings for gas producers. GWOSDZ. *Feuerfest*, **2** [5], 45 (1926).—Producers operg. with strong or forced draft require linings carefully designed and constructed to prevent the escape of gas. High refrac. mat. only necessary in special cases. Producer mounted on vehicles must have lining especially designed to withstand jarring. A description is given of a number of producers filling these requirements. F. A. W.

Methods for increasing stack draft. A. BURGHARDT. *Feuerungstechnik*, **14** [16], 191 (1926).—Stack draft can be reduced by (1) choking by soot and ash, (2) connecting

additional flues, (3) cracks in brickwork or dampers, (4) drop in temp. of flue gases on account of thin flue walls, (5) unsuitable location of multiple flue connections. If height of stack is increased it is advisable to continue up straight and not further reduce the cross-sectional area. Forced draft not suitable for continuous operation. A separate refrac. lining inside the stack increases draft by preventing the flue gases from cooling too rapidly. F. A. W.

Gas producer operation. F. E. LAEHY. *Fuels and Fur.*, **4** [7], 837–40 (1926).—So many factors enter the efficient opern. of gas producers that even with the many improvements in producer design instruments can be of great assistance in efficient control and in production of the most satisfactory gas. These instruments are valuable in that they enable the operators to check and reproduce a given and desired practice. They can also be used to analyze fur. operations and to det. the magnitude of peak loads, occurrence, comparison of day and night turns, and fuel required per ton of output as well as the best gas for the operns. R. M. K.

Sands for special purposes. ANON. *Chem. Age*, **14** (China Clay Suppl.) 9–10 (1926).—Special sands must generally be clean and free from excessive fines and clay coating. For commercial use the prepn. generally requires washing, drying, and screening. Dry screening is more effective than wet, because the surface tension of water causes fine particles to adhere to larger ones and sep. with the oversize. For close sizing, vibratory screens are generally used. The principal special sands, and their chief specif. requirements are enumerated under engine, abrasive, potters', roofing, flooring, and standard sands, and sands for oxychloride cement or plaster, chem. and metallurgical use, pulverizing, and possible by-products. The possible lines for application of research are in the prepn. and utilization. E. E. P.

Retaining walls and geostatic theories. F. W. WOODS. *Engineer*, **141**, 604–605 (1926).—Mathematical calculations of stresses exerted by earth against retaining walls based on the assumption that it acts as a loose, dry, granular powder are not a satisfactory basis for calcg. strength requirements, since it does not represent the usual natural condition of earth. W. suggests a method of reckoning earth thrust, indicating a press. equivalent to that of a fluid weighing 9.7 lbs. per cu. ft., and using a factor of safety of 2.67. E. E. P.

Technical education in clay working. ANON. *Ceramist*, **8** [2], 107–14 (1926).—A discussion of the problem of giving proper training and education to boys and young men entering the different branches of the clay-working industries. The advances in tech. education in the U.S. during the past year are given and the existence of the same problem in England is pointed out. Two courses are discussed; that of having special classes in clayworking in the tech. institutes and that of vocational training given to boys prior to their leaving school and entering the works. The situation caused by the decline of the apprentice system is described. A. E. R. W.

Glazed ware at the Building Exposition. ANON. *Brit. Clayworker*, **34**, 60–61 (1926).—The quantity of sanitary ware exhibited at Olympia was somewhat less than on previous occasions but the quality was improved. It was shown that manufacturers were devoting more attention to efficiency and less to novelty of design. A general improvement was noted also in the gloss of sanitary ware. The fireplaces were practically all in excellent taste and the glazed terra cotta exhibits were more novel and striking, while the glazed wall tiles were shown in some really beautiful effects. H. G. S.

Prophylaxis in lead poisoning. D. MCKAIL. *J. Ind. Hyg.*, **8**, 74–77 (1926); *Chem. and Ind.*, **45B**, 302 (1926).—A mouth wash and drink designed to ppt. Pb as sulphate. H. H. S.

PATENT

Preparation of rare metallic oxides. JOHN ALLEN HEANY. U. S. 1,592,459, July 13, 1926. The method of prepg. a porous body of highly refrac. mat. for use in elec.

appliances, which consists in subjecting the body to heat in the presence of a molten substance solid at normal temps., until the gases in the pores have been replaced by said molten subs., allowing the body to cool and said subs. to solidify in the pores thereof, incorporating the same in a container, volatilizing the subs. filling the pores, and simultaneously evacuating the container.

BOOK REVIEW

Pottery and Porcelain—A Guide to Collectors. FREDERICK LITCHFIELD. MacMillan Company, New York, Price $9.00. A book written as a guide to collectors, may at first thought seem to be of little more than superficial value to the pottery manufacturer or to those responsible for the decorative work in the various factories.

A certain manufacturer or art director may possess an interest in decorative ceramics to the extent of the processes within his own practical experience, while consciously or unconsciously excluding any acquaintance of historical development with its accompanying knowledge of the processes and methods of potters of other countries and periods.

Such a type of mind however, is incapable of producing anything that is outside the average commercial standard of decorative ceramic work.

The pottery decorator or designer who is not closely familiar with the history of ceramic development and who is unable to recognize outstanding types as a matter of course, is, to say the least, hopelessly incompetent, however skilled he may be in his particular field; and the manufacturer living in a similar state of innocence is most definitely limiting his own chances, so far as his decorative policies are concerned.

When a business man embarks on a commercial undertaking of any importance, he is particularly careful to make a thorough investigation of all the conditions involved.

It would then seem that the business man engaged in the somewhat risky occupation of ornamental pot making, whether utilitarian or otherwise, would at least acquire a general knowledge of what has been done in the past, and is being done at the present time in the same line of endeavor.

A recognized museum authority recently recommended that pottery manufacturers acquire authentic historical examples for the purpose of placing these before the workmen in the factories. The idea being that the workmen would develop a sense of beauty which would somehow result in improving the decorative quality of the product. However this may be, it is fairly improbable that the average manufacturer would dig down in his "jeans" for the wherewithal to acquire expensive examples of ceramic wares. But there is one practical suggestion that he could follow for the advantage of all concerned and that is to acquire books which will give those interested a comprehensive historical acquaintance with various ceramic types and also a fair basis of comparison with surrounding activities.

"Pottery and Porcelain" by Frederick Litchfield, is a book which should be in the library of every clay working factory producing decorative work of any description.

The first three chapters furnish a rather sketchy, historical outline of pottery making, from ancient times to the eighteenth century.

The remainder of the text deals with just that type of information which is of particular value to collectors. The amateur is told how to form a collection, and how to detect spurious examples. There is a chapter of values and prices and a glossary of terms used by dealers and collectors.

While all this material may not be of primary interest to the manufacturer, the book is full of condensed descriptions of the more important European factories, and the chief value of the book to manufacturers lies in the many careful selected illustrations of examples of various periods. The selection is by no means comprehensive. However, there is ample authoritative data, both in illustrations and text to supply the practical potter with a good working background of ceramic development from ancient times to the eighteenth century.

F. H. RHEAD.

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EDITORIAL

TOTAL EARNED PROFITS DUE ARE NOT REALIZED IN PRESENT SCHEME OF CERAMIC EDUCATION

During September and early in October the ceramic departments in eleven American universities will open laboratory and classroom doors for instruction. The university officials and the ceramic instructors will this year, as in the past, do their best to return the largest possible profit to those who finance these ceramic schools. They, as well as those who pay the bills, earnestly desire to have the most productive educational program.

The average cost per engineering student in America last year approximated $610.00 including upkeep of plant. Of this amount only $172.00 was paid by the students as fees. The total cost to the universities and student per student per year ranges from $1500 to $3750. Thus it is that tax payers and the parents of the students are investing heavily in each student in our engineering schools on which investment they rightfully expect the largest possible return to society in general. This large investment in money per year per student is only one of the tangible means of estimating the responsibilities placed upon the college instructors.

The courses of instruction given in each school are what the instructors believe for their peculiar conditions and opportunities to be the best. A large part of the trust and obligation placed upon these in-

structors is in the devising and the conducting of those courses which in their opinion will best equip men for service in the ceramic industries. With this trust and obligation is a license to be arbiters and it is in no wise a disregarding of this license that proposals of educational ideas are made by this SOCIETY.

The "voice of the people" is more effective in the elementary schools because they are closer to them by personal contact and through direct tax levies. This makes the elementary schools more sensitive to changes in social and business requirements. The universities are more removed from the tax payer. Their cost for support is not shown on tax duplicates. The universities, being further from the "people," are less sensitive and responsive to changes in human and industrial affairs; and this is as it should be, but this greater independence and apartness of the universities makes imperative that the "people" have some agency other than political to translate their needs into terms of curricula and instruction.

The "people" do not voluntarily make known their wants. In fact, their wants are with difficulty translated into recommendations because the "people" know little of the university policies and methods. Unless they have some organized agency of their own they must rely wholly and confidently on the university authorities to know and to meet their wants. In this respect both sides are innocently at a disadvantage and are without incentive to understand and to make corrections. It is the duty of organizations such as this SOCIETY to study the situation and to make recommendations.

The Committee on Education of this SOCIETY has considered ceramic instruction in (1) high schools, (2) vocational evening classes, (3) foremen institutes, (4) extension by person and by correspondence, (5) short term institutes (2 weeks), (6) short industrial collegiate courses (2 years), (7) undergraduate in ceramic art, and in ceramic engineering, (8) graduate courses in ceramic science, and (9) plant demonstration of results of investigations.

(1) High School Courses The 1925 records for Ohio show a large loss in students as follows: 149,000 entered 1st grade, 89,000 were in 8th grade, 77,000 were in 9th grade, 34,000 were in 12th grade.

This is a loss of over 77% of the pupils between the first and twelfth grades. What becomes of these boys and girls who do not continue through the high school? Why do they withdraw from school and how shall they be given the educational training so necessary, and increasingly so, for advancement in industrial and trade positions? This is a subject for investigation not within our scope.

Obviously these pupils cannot return to day schools. Night classes and vocational schools are their only opportunities, and for those who will remain through the high school there should be trade schools. Such night and trade schools are conducted for many kinds of trades. Why not for ceramics?

(2) Foremen Institutes Foremen institutes in centers where the number would warrant, and extension courses by lectures and correspondence to those who cannot travel to the centers are means of instructing factory employees in application of the investigations. It is as important that knowledge shall be applied as it is that knowledge shall be made available. For every dollar spent in investigations another dollar should be used in making findings understood by the factory operators and applied in factory operations. This rightfully and logically is a task for the universities in collaboration with the industrial executives.

(3) Short Term Institutes and Short Industrial Courses The two-week winter courses and the two-year industrial courses in universities have made it possible for many persons who could not have taken a full collegiate course to equip themselves for original thinking in ceramics. The school training in ceramics of several of our leading technologists was limited to a two-year industrial course.

Registrations in collegiate short-term and extension courses in engineering in this country during the year 1924–25 was 20,078. Since the average duration of these special courses was less than two years it is apparent the total number of individuals benefited is nearly equal to the number of regular under-graduate pupils in engineering. The universities are making such courses available to students in other vocational lines. Why not in ceramics?

Dr. W. E. Wickenden, director of investigation for the Society for the Promotion of Engineering Education stated the following in his report dated June, 1926:

> Plainly our difficulty is not that we have too much technical education but that we have yielded to the temptation to make a fetish of the standard collegiate program and degree. The most immediate need is to provide for large numbers of young men a briefer, more practical, more intensive training than that of an engineering college, a training broader than that of a trade school, and quite distinct from that of an academic junior college. There are two types of young men to be provided for in such schools: one already employed in industry but desirous of giving a limited time to intensive technical training to facilitate his progress in chosen lines of activity, and the other, the secondary school graduate who does not desire an arduous theoretical preparation, but seeks to enter the industrial field through its junior technical or supervisory services and work his way up.
>
> There is a small group of technical institutes of noncollegiate type doing excellent work in the field described. Their graduates are able to enter active life at a fairly early age, with assured earning power, with ample time for thorough ground-

ing in experience, and with the willingness to accept the régime and environment of operating organizations. Their records indicate that they are able to rise through the ranks to positions of considerable responsibility and that a fair number of them achieve distinguished success, though more often in the line or operating fields than in the traditionally "professional" field of engineering. The present supply of men from these sources is very small, while the demand which would certainly be created if industry undertook to adjust itself to recruitment of this kind might be expected to outrun that for college men with engineering degrees.

In every other advanced country this type of technical education is very generously provided for, and it would seem to be the complementary element most needed in our own system. Great numbers of students who enter our colleges with a valid impulse toward technical work, but without certain qualities demanded by a long and arduous theoretical training, might do themselves credit in a briefer and more practical program. With all due allowance for the college-struck attitude which prevails in our youth, it seems probable that a very much larger number of them might be directed to such a program if it were more widely provided, given suitable formal public recognition by the public and the engineering profession, and its merits set forth by adequate publicity.

(4) Undergraduate Degree Courses

The Committee on Education has drawn attention to the importance of courses of instruction in which ceramic wares are the topic headings. There is a need for training in product visioning and in means of obtaining products of specified quality, form, and decoration. Ceramic technologists need to know what fundamental science knowledge to employ in the production of wares. This calls also for knowledge of the requirements to be met by the wares.

Such courses for want of a better name have been styled ceramic art.

Quite distinct is the need for courses in ceramic engineering which will give the students a thorough ground work in the engineering of plant construction and operation. The ceramic industries have been slow in making application of known fundamental engineering principles largely because our schools have not given sufficient attention to strictly engineering problems in ceramics. Our engineering courses have been too much of a compromised effort to train each student as a technologist and engineer with the result that except by virtue of unusual natural talents, the graduates of such courses are not as well equipped as they should be in either ceramic technology or engineering.

The third type of college training needed in ceramics is ceramic science. Attempts have been made to give courses in ceramic science as distinct from ceramic engineering but not with success. The purpose of such science courses is to train men for research service. To qualify for such service the graduate must have a thorough training in the methods of using science facts. Such a training requires the full time of a four-year course in the sciences and allied subjects plus a graduate course in which stress is given to applying the fundamental science concepts to ceramic problems.

To produce ceramic wares of highest quality at lowest cost to meet specific requirements these ceramic industries need men especially trained in engineering, art, and science, respectively, and it seems to be the height of folly to expect most effective results from a single course in which all three of these distinct types of training are attempted.

It would seem important that ceramists should get their share of returns from the $60,000,000 now being spent annually for collegiate training in engineering, science, and art. This $60,000,000 is an investment by society from which society expects the ceramic workers to obtain their share of returns.

The Committee on Education will continue its studies of these several educational schemes with appreciation that no single scheme will be useful to all persons nor in all places.

PAPERS AND DISCUSSIONS

KILN SLABS BY SPECIFICATION[1]

By R. L. Clare

Why can we not buy our kiln slabs on some sort of a guaranteed basis? Why do we have to buy a fairly expensive product with no idea as to whether it will serve our purpose well or poorly? The only answer to these questions at the present time seems to be "Buy from the manufacturer that you think produces the best slab, and hope that your judgment is good." That brings up further questions: What constitutes a good slab? How many firings should a good slab last under a given set of conditions? Why can we not buy slabs with a longer life?

With these unanswered questions in my mind I approached the slab manufacturers in the East with the proposition that we would be glad to buy slabs on a guaranteed basis similar to the buying of graphite crucibles, and that if a slab could be guaranteed to last 30 firings, instead of 20 firings, we would be glad to pay considerably more for it. This seemed to be a practical proposition, as we found from our records that the life of our slabs varied considerably.

There was a considerable difference in the life of those purchased from different manufacturers, a considerable difference in different lots from the same manufacturer, and a considerable difference in individual slabs of the same lot from the same manufacturer. Of course, we realize that the handling of the slab is a contributory cause to its failure but it should be physically strong enough to stand ordinary rough handling.

An example showing the wide variation in the life of slabs from the same lot from the same manufacturer, is as follows: We started a new kiln late in 1924 and equipped it with new slabs of the same make and from the same shipment. The approximate number of slabs used was 500. Fifteen of these slabs failed on the first firing and this number increased steadily with each succeeding firing, until at the present time, after some 25 firings, the loss is from 30 to 35 with each firing. This seems to indicate that under our conditions of firing and handling, these slabs are good for an average of at least fifteen firings. This also indicates that some last only one, two, or three firings, while others must last thirty or more firings to bring up the average. This is very startling.

[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (Terra Cotta Division.)

Now, as to the proposition to the slab manufacturer: most of them were very frank in stating that they did not know how to improve their slabs—that they did not know why some should last longer than others, and, consequently, were in no position to guarantee any specified number of firings. I might also state that the silicon-carbide slab manufacturers also refused to guarantee the life of their product. None of the manufacturers seemed to know much about the number of firings their product should last. We tried one very reputable firm in the Middle West, got in a sample lot of one hundred slabs, and found them to be so weak and defective that we were afraid to trust them in our kilns for one fire.

We sympathize with the manufacturer in his lack of knowledge of the life of his product, as he has no control over the variable conditions under which the slabs are used, or any access to the records of their life.

All of the manufacturers were very willing and anxious to coöperate in the securing of accurate data regarding their material and promptly furnished various sample lots of slabs of different mixtures for testing.

These are the facts which prompted my bringing this subject up for discussion. Does any one know of any manufacturer who will guarantee his product for any given set of conditions? Does any one know what particular physical or chemical properties are necessary in a good clay slab? Each manufacturer has his own peculiar methods, but which is right?

Does any one know of any test that can be applied to a slab that will indicate whether it will last well or not?

To my mind, this is not a refractory problem, nor one entirely of pure physical strength. I think the coefficient of expansion should be studied; also the tensile strength, and toughness, as indicated by the quenching test.

We hope by this discussion to lay the foundation for some future work along very definite lines in order to try to determine just what qualities a slab must have to last well. Also, to try to determine some quick and definite test of a good slab.

We believe such data will be of value to the slab manufacturer in producing a better product, and of value to the slab user in reducing the ultimate cost of the slabs used.

FEDERAL TERRA COTTA COMPANY
WOODBRIDGE, N. J.

KILN SLAB SPECIFICATION[1]

By F. B. Allen

In an off-hand manner, one thinks of the terra cotta slab problem as one of easy solution. It appears to be one in which the service conditions are not severe and also one in which the clays and grog most readily available would suffice. But such is not the case. The conditions are severe; that is, the temperature reached, the duration of the fire, the number of firings expected, and the load to be carried are rigorous. Consequently the mix material must be selected with care and all the manufacturing operations carefully watched.

But even with this effort at control, variations appear. Slabs from the same batch will give a longer service than others from the same batch. This is difficult for the manufacturer to understand, as in our case the mixture is prepared in lots of approximately five hundred slabs. They are molded under the same physical conditions and the other manufacturing conditions such as drying, setting, and firing are as near the same as we can maintain. We admit that it is impossible to have absolutely identical conditions from batch to batch and from day to day, but we do make an effort to have the same molding conditions, the same drying conditions, etc., as we well realize that a satisfactory product cannot be produced by careless methods.

This, then, leads up to the consideration of what constitutes a satisfactory slab. How many terra cotta plants have a reliable record as to the life of their slabs? How is this life determined? Is it not generally based upon the number of slabs purchased in a given time, divided by the number of firings?

Information of this sort should be brought out here so that a starting point may be had in the determination of the service conditions as well as the definition of a satisfactory service.

Few manufacturers would be willing to sell slabs on a guaranteed basis until these service conditions are more clearly defined. Personally, I believe that this present coöperation between the manufacturers and the users will lead to the development of a better slab so that a guaranty will not be necessary. The slabs will give a longer life, not only because of their proper composition and method of manufacture, but also because the users themselves will take every precaution to see that these necessary "evils" are carefully handled.

In conclusion (it is hardly necessary to say it) we are pleased and anxious to coöperate, in the fullest sense, with the terra cotta manufacturers in the development of a satisfactory slab. We will "go the

[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga. Feb., 1936. (Terra Cotta Division.)

limit" to obtain a correct solution of the problem, because we know that such a solution will be a benefit to all parties concerned.

M. D. Valentine and Bros. Co.
Woodbridge, N. J.

EFFICIENT DRYING AND ELIMINATION OF WASTE IN THE MANUFACTURE OF SEWER PIPE[1]

By Charles A. Millar

Many plants visited by the writer during the past ten years have been enlarged and remodelled to suit varying conditions, but usually retaining the primal conditions which bring trouble. An architect said to me one day, "Here is my ideal home, and I hope to have one of my clients build from it some day." In the same manner I have an ideal and perhaps some day we might see a perfect drying factory for the best ware made in the world.

Location of Boiler Most sewer pipe plants today have the boiler room in the main building, with possibly one or two fans to distribute heat when the factory is not working. This is all wrong as too much heat is had in one and not enough in the other parts of the building. The ware is checked before it reaches the kilns and work in manufacturing is lost, and must be done over again with additional expenses.

To my mind it is impossible to have efficient drying in a plant with the boilers and fans inside the main building. The boilerhouse should be located outside with full control of all exhaust steam and traps for return to the boilers. It would be a great saving to be able to put the exhaust from pumps through some part of the factory on a floor that was not in use during the day. In our plant it runs under the first floor in cool weather, passes out through the clay sheds, and is lost altogether.

It would seem that a square building is needed to meet requirements of one to four presses. Ample elevator space, the ground floor cemented with steam pipes through, or under, and the balance of the floors slatted with pipes under each so that exhaust steam could be used during the day and live steam at night, should make an excellent drying plant.

Prevention of Roof Drip To remedy the dropping of water from inside the tar and gravel roof caused by condensation, an engineering firm installed an engine and suction fans on the ground floor with a galvanized iron pipe six feet in diameter, extending to the top floor and a network of pipes to all corners of the floor. This must

[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (Heavy Clay Products Division.)

have been installed before it was discovered that heat will ascend as the idea was to draw all moist air down four stories, and force it to the outside through a duct in the basement. It must have cost many thousands of dollars to install. It was utterly useless.

We installed about eight thousand feet of two-inch black iron pipe with half a dozen valves so that it could be shut off or turned on as needed in the different sections. Pipes were placed 1½ feet from the ceiling, and all to drain back to the boiler well. It is today the best and most even drying floor we have in the factory and the cost was about six hundred dollars, exclusive of the men's time. We had lost more pipe and trap each winter from water dropping on them than would pay twice over for this installation.

A plant so equipped that steam can be turned on in quantities to suit the tender clays and adjusted to the needs of all clays by the turn of a valve seems the ideal for drying purposes. While the use of waste heat from kilns may do for common brick manufacturing and make money for the user, it does not seem practical for sewer pipe as the sulphur and gases are likely to discolor the pipe and spoil them for taking a good salt glaze.

Economy from Water Softening

50 to 55% efficiency is about all that is obtained in many boilers, and some are operated at 30% and below. Very few sections of the country have a water that will not form scale and for every layer of scale, more coal is required to form steam. We have a battery of three boilers which required twelve to thirteen tons of coal every twenty-four hours. We investigated a water-softening system and found one plant which formerly used twelve boilers was now running on six, and another plant had reduced from three to two boilers, with more steam than before. We installed a soft water system costing about $1250.00. After it had been operating about two weeks and all scale had dropped off and been cleaned out, we cut our coal to nine tons and in warm weather often get through with eight tons.

We formerly let one boiler out every Saturday noon, washed it out Sunday, and lit it again on Sunday night. At the present time we open our boilers about once every four months to see if they are mechanically all right but we find no waste matter in them. We have saved the engineer's time as there is no washing to do. We save and are still saving at least three tons of coal per day. And we have efficiency all the time.

Smoke Elimination

We used for many years either mine-run or ¾-lump for fuel, costing us from $6.00 to $6.50 per ton, but as population increased in our neighborhood and the demand for less smoke and soot became more insistent, we installed last spring

a "Coppus" blower under each boiler, and now use one-half slack and half lump, costing about $4.50 and $6.00 per ton respectively, and have to a great extent eliminated the dense smoke, as we have had no complaints since.

Loss of Exhaust Steam

Another source of great waste is the loss of all exhaust steam from the presses. Live steam at 125 lbs. pressure costs gold dollars to produce and I have wondered many a time if compressed air would not be more economical? I have read very recently an account of the manufacture and installation in many plants in Europe of "Ruth's" steam accumulator, and already some are in use in America. I am sure there is more room in the sewer pipe business for such equipment than almost any other line of manufacturing, with connections large enough to the exhaust on the presses so that it could get away quickly and without back pressure. It would be a wonderful saving on the coal pile. This is more of a suggestion than advice but it is well worth time and consideration.

Falling Stands

For many years we had one way only of setting our kilns and it was no uncommon thing to have one or two stands of pipe down in rotation. Setters were blamed for it. Firemen were blamed for it. Fast trains travelling past and shaking the ground were blamed for it. But they went down just the same. On examination it seemed as though they started going where the 8- or 9-inch pipe were set in the first rows out from bags. I instructed the setting gang to put in four stands of large pipe 15 or 18 inches in diameter as a stay for the small pipes. Since that day we have fired off between six and seven hundred kilns and have not seen a dozen pipe of any size shifted or down.

Broken Pipe

Our broken pipe and rings after being fired, are kept in a pile and wheeled to a dry pan, ground over, and used for grog in the larger sizes of pipe, and the finer screenings used as a filler to make a jointing compound for use by contractors in laying drains.

ONTARIO SEWER PIPE AND CLAY PRODUCTS, LTD.
MIMICO, ONT.

ART AND THE MANUFACTURER[1]

BY F. J. M. KOENIG

In England until the beginning of the Eighties there had been scarcely any unity among decorative artists. The earlier efforts of

[1] Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Atlanta, Ga., Feb., 1926. (Art Division.)

William Morris were the source of the development of the "Arts and Craft Society," founded in 1888.

Walter Crane wrote on decorative painting and design and on wall-papers, William Morris on textiles, Robinson on fictiles, Somers Clarke on stone and woodcarving, stained glass and table glass, Benson on metal work, etc.

There, however, they always had in mind art-craft production. In Germany they were already farther advanced. By starting a work society, "Werkbund," the German acknowledged the importance and the necessity of the coöperating of the artist with the industry. The advantages and the results of this "Werkbund" before the war, were the cause of the founding of the "Design and Industry Association" in 1915 under protection of the English Government in England.

The success of this German coöperation was absolutely recognized by Sir Leo Money Clutton, Brock, etc. Henry Clouzot wrote in "Le Mercur de France" about "French Modern Art Industry" and said that it was nearly impossible to compete since there was a continuous imitation of old styles.

The logic and the concatenation of facts make it necessary to use the new models and designs if we want to apply art to modern life.

We know that new methods of working, new machines, and new wants develop a new art of forming. The artist who does not want to be acquainted with the different new methods of working and the peculiarities of the material he is going to use, is just as unprogressive commercially as the manufacturer who does not want an artist in his factory. New art is not to make a soup basin in the shape of a Grecian amphora, nor a dancing girl jumping from a flowerbowl, nor to try to adorn a deformed shape by using little roses or forget-me-nots on the surface. By all means there is more and better to do.

In 1918 I made a study of the Japanese ceramic industries. I visited the simple but artistic school for ceramics at Kyoto. The friendly director, Dr. Uyeda, showed me over the school and it was a big surprise to see the two departments, one with old and new beautiful Corean, Chinese, and Japanese ceramics and the other with American and European industrial ceramics.

The purpose was to show students and manufacturers how to work and how not to work. Returning to our ceramic industry, we can divide it into three methods of production. First, the old handwork, for instance, the potter's wheel, the hand-weaving loom, etc. Second, the absolute mechanical production. Third, the combined machine and hand labor.

The first one is used only where the second and third do not lead to the desired shape or decorative result. The second only for utilitarian

wares. The third as a form between those two, for instance, Wedgwood, Lenox, Copenhagen, etc. The first method gives a remunerative result in the hands of an artistic artisan only. The second production method is the most neglected artistically. It requires the knowledge and talent of the artist if it is to be beautiful. It is very desirable for him to have learned the first or the third method. In that case, he will not be a stranger in the factory. Neither can he be a stranger in society, but he must be in touch with the continuous changing wants. Now the question is how to obtain the so-desired and needed artists.

In northwest Europe for the past forty years, there has been at least one art and trade school for each five thousand skilled workmen laboring in the industry. Not all the students coming from those schools will be artists, but they will be at all events good usable, skilled workmen.

Further, the industries give the teachers orders for decorative designs and models to keep them in touch with the industries. Competitions as now announced by the Art-in-Trades Club of New York for wallpapers, were held, especially in Germany before the war, to obtain good working models and decorations.

"Wanderausstellungen," traveling exhibitions, of the best results of the modern art industries in different countries were held in German industrial centers. These were similar to those planned to be shown in this country of modern French applied art.

Summarizing we can say that for improvement of quality production which can stand foreign competition we need:

1. A greater number of schools for artisans, these to include art training.

2. An intensive coöperation of the Government when traveling exhibitions are held of foreign industrial products, with lectures by competent persons.

3. Enough interest from the manufacturers to hold contests to get better models and designs.

4. Love and interest from the workmen for their chosen subject. The financial profits obtained by the German industry furnish proof of the worth of these methods to improve quality production.

Just now I find an old *Studio* and read: "Art is a living force, not a dead language and our duty is to keep it alive. We must not fail in that duty through mistaken respect for the past."

HAEGER POTTERIES
DUNDEE, ILLINOIS

CERAMIC PRODUCTS IN LANDSCAPE ARCHITECTURE[1]

By P. H. Elwood

It is encouraging to note the artistic progress being made in all the crafts. This is accompanied by a greater appreciation and demand on the part of the public for the products of the ceramic art. Then too, it is a noteworthy fact that color is being used and is becoming widely recognized as an essential element in the structural design and embellishment of buildings and gardens.

America's architects and landscape architects have often failed to really adapt styles to local climate and needs. Houses and gardens are now built for June, and the "Perfect Day." What are we to do the rest of the time? Swelter under the eaves of a bungled bungalow in the middlewest, roofed with the hottest material available, and in a sun-baked and dried-up pseudo English garden, or under a cool, tiled roof and in a shady, paved, breezy, semi-enclosed garden?

Social requirements also differ from the Renaissance or Victorian days, even in the United States. The position of women no longer calls for the privacy and seclusion of earlier times. The absence of dangers from outside attack by marauders and hostile bands eliminate the necessity for completely enclosed gardens. Streets are wider and partake more of the nature of parkways today. The development of electrical and motor driven machines has radically broadened our control of natural forces, enlarging our sphere of outdoor enjoyment. The good life is not possible without spending much of it in the out-of-doors. This is becoming more than ever recognized in America. The present therefore is a propitious time for any art or industry so closely associated with buildings and gardens as is ceramics. This fact is more timely, perhaps even acute, as a result of the pronounced and accelerated development in our southern Pacific and Atlantic regions, particularly in Florida and California. This is an important movement and it has just begun. What are conditions in the country as a whole? We have patiently but indifferently suffered in ignorance or inertia. Why have we not more nearly made comfort and enjoyment possible throughout the year in every state in the Union?

While our forests are rapidly disappearing we still use wood in nearly all house construction in the Mississippi Valley, the region farthest away from both coastal forest regions. Why not a more general use of brick and tile in their many variations of texture, color, and quality, for equally variable uses such as roofing, flooring, paving in both indoors and out, in the construction of steps, fountains, porches, pools, as well as decorations for indoor rooms and patios?

[1] Received Mar. 30, 1926.

Before the landscape architect can tastefully and appropriately use many products of the ceramic art, the architect must lead the way with a greater visible use of terra cotta and tile in building construction. Then the landscape architect can embellish the setting and surroundings effectively.

First in importance to the landscape architect is that the architectural treatment of the house be in harmony with such features as tile-roofed shelters, arches, inlaid tile pictures or panels in walls, tile pavements, steps, copings, tile-lined pools, tile seats, benches, and fountains.

When you speak of tile work either interior or in the garden many at once think of Andalusia, Spain, or the French and Italian Riviera with their more or less general use of tile. Of course a more conservative color scheme is necessary in connection with an English type of house and garden development. However, even in work inspired by English and Dutch or French precedent, a more liberal use of tile and brick both indoors and out-of-doors would count for beauty, and comfort as well as ease and economy of maintenance. This factor of economical maintenance in America is becoming important as labor becomes more and more expensive and scarce.

An attempt to enumerate the various products of the ceramic art which the landscape architect desires most might be somewhat simplified by a résumé of those things he avoids. These negative desires, in a word, may be summed up by saying that the landscape architect does not care to use anything which at best is only an imitation of something else. Some say immediately, "concrete."

Yes, I do mean that concrete should never be used where it is an attempt to imitate stone or marble. There is no reason, however, why concrete cannot be used in many forms in the garden, especially for benches, large receptacles and pools. The design of all such features should be adapted to the material used. In other words, do not design for terra cotta or marble, and build of concrete. It is worse than diamonds of paste, because it does not even look the part.

This leaves for final discussion a group of ceramic products considered by many to be of first importance. That is pottery. From a commercial viewpoint it seems logical that we first stimulate and encourage the quantity use of more or less standard products, such as tile for roofing and floors and pavements, and a more general use of brick in the garden before we demand the refinements and embellishments, The former, however, should make possible the latter, because of economic advantages.

The selection and use of pottery in a garden is as much an art as the placing of high lights in a picture or the arrangement of rich porcelain on a marble mantle.

Here again let us strive not necessarily for the original but at least for the appropriate. Many innocent and well-to-do newcomers to Florida, and in other parts of the country, apparently still believe that a smattering and scattering of tile and Italian or Spanish jars and vases about their stifling and sunswept patios creates for them a Spanish atmosphere. Nothing is more absurd. If they have properly and skilfully planned their houses and gardens to control the direct and indirect sunlight, the advantageous use of air currents and shade, and have met their own luxurious personal and social needs, they undoubtedly have found, as the Moors of Spain did centuries ago, that the generous and general use of pottery provides a real service.

Nearly every formal garden in whatever style is enhanced by a free use of plants in ordinary terra cotta pots. They give to the garden variety and personality, and relieve the rigidity of plan. Also large tera cotta oil jars so common in Italy and Spain are effective elements in formal and occasionally even in an informal design. But why should we import such bulky products when all we need is the idea, the design? Surely our potteries can reproduce these. One trouble with the American product is that it is "too perfect." A landscape architect once remarked to me "he always preferred the culls, the imperfect, discarded jars" which impart at once an old world charm born of handmade individual work.

Then passing on to the more delicately designed and glazed pottery such as is imported from the furnaces of Canti-Galli Deruta in Italy or Zuloaga in Spain. A touch of the work of such master craftsmen in any home or garden lends to it an undeniable distinction. Until we can better adapt our designs to our own traditions, customs, and landscapes, I say import by all means, but already I have seen most beautiful original designs, from within our own borders. What could be more appropriate or effective than some of the famous Rookwood, Zanesville, or Marblehead products or the work from the Benton or Newcomb potteries of our own south?

These efforts should be encouraged by the landscape profession, and the products advertised and more generally used in an attractive way that Americans, ostensibly so patriotic, would have a great opportunity for active demonstration of appreciation for American-made pottery.

Dept. of Landscape Architecture
Iowa State College
Ames, Iowa.

ACTIVITIES OF THE SOCIETY

NEW MEMBERS RECEIVED FROM JULY 16 TO AUGUST 15

C. F. Allehand, 1300 N. Maryland, Glendale, Calif.

Ankurnath Banerjee, Mugma P. O. Dist. Manbhum, India, Supt. Behar Fire Brick & Potteries Co.

Henry Clay Fisher, Norton Company, Worcester, Mass. Ceramic Section, Research Laboratory, Norton Company.

David C. Haeger, Keystone Bldg., Aurora, Ill., Pres. and General Mgr. Haeger Brick and Tile Co.

Dorothea Warren O'Hara, Appleton Lane, Darien, Conn.

Membership Workers' Record

	Personal
M. F. Beecher	1
Myrtle Merritt French	1
H. J. Knollman	1
H. R. Straight	1
Office	1
Total	5

NEWS FROM MEMBERS OF THE SOCIETY

Erling E. Ayars, formerly active in the Refractories Division of the SOCIETY, writes from Coconut Grove, Fla., that he has become Editor and Manager of the *Coconut Grove Times*, a weekly newspaper.

A. Lee Bennett, who has been with the Northern Clay Co., Auburn, Wash., has removed to Glendale, Calif., where he is located at the Tropico Plant of Gladding, McBean and Co.

H. B. DuBois, formerly with the Standard Tile Co., Zanesville, Ohio, is now with the Pennsylvania Pulverizing Co., in the capacity of ceramic engineer.

Authur F. Gorton, recently with the Buckeye Clay Pot Co., Toledo, Ohio, has moved to San Diego, Calif., where he will desert ceramics for a while and enter the real estate business.

F. P. Hall, formerly research chemist for the Standard Oil Co., New York City, has moved to Columbus, Ohio, where he has accepted an appointment with the U. S. Bureau of Standards as research associate chemist.

Roy A. Horning, Chairman of the Heavy Clay Products Division, has left the Lancaster Brick Company, Lancaster, Pa., and is now associated with the Armstrong Cork Company, Beaver Falls, Pa.

Frank Humpel, of Grand Haven, Michigan, has removed to 1126 E. 47th St., Chicago, Ill.

R. B. Ladoo has removed from East 8th St., New York City to 84 22nd St., Jackson Heights, New York.

Samuel Wilkinson has moved from Trenton, N. J. to St. José, Calif.

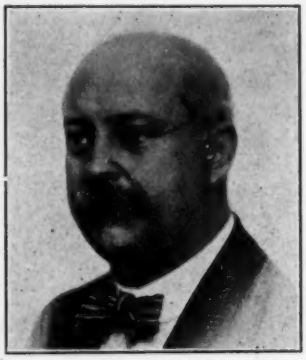
The Denver Terra Cotta Company, a Colorado corporation, has changed its corporate name to The Northwestern Terra Cotta Company. The change is solely one of name, such change being deemed desirable in order to conform to the name of The Northwestern Terra Cotta Company, an Illinois corporation, which continues to own all of the capital stock of the corporation formerly known as The Denver Terra Cotta Company. There has been no change in the organization, management, or stock ownership of the corporation last referred to.

THEODORE A. RANDALL

Born June 11, 1857	Died July 23, 1926

Life Sketch

Mr. Randall was born at Akron, O., June 11, 1857, and spent his early boyhood at Utica, N. Y. He came to Indianapolis with his parents when thirteen years old and attended Northwestern Christian University, now Butler University, from which he was graduated in 1874. He was employed in his father's office as an accountant and later was cashier for the Indiana agency of the New York Life Insurance Company.



In 1884 he founded the firm of T. A. Randall & Co., and started the publication of *The Clay-Worker*, the first magazine devoted to the brick, tile and pottery industry. Two years after founding the magazine, Mr. Randall organized the National Brick Manufacturers' Association. He was its first Secretary and held the same position until his death. His long service as Secretary is said to be without parallel in other industrial associations.

An Estimate of Home Town Associates[1]

To say of a man after his death that he will be missed and mourned is a commonplace, for it may apply to some extent to nearly every man. To say this of Theodore A. Randall means that a host of people in Indianapolis where he lived for more than half a century will feel that they have lost a friend; many others with but a casual acquaintance will long recall him as one whose passing greeting was more than a mere formal recognition; with his "good morning" went a friendly intonation and a smile that carried cheer. It has been said of him that he simply radiated friendship.

It is likely that many who knew Mr. Randall in political, Masonic and club circles and in social life had but vague information about his business career. They knew, perhaps, that he owned and edited a magazine called *The Clay-Worker*, but being a trade periodical, it meant nothing to persons not connected with any of the industries it represented, but the history of the development and influence of that periodical would undoubtedly make an interesting story of itself, while his handling of it and promotion through it of brick, tile and pottery industries meant an ability on his part that put him

[1] Editorial in *Indianapolis Star*, July 26, 1926.

in high esteem of manufacturers in such lines. Started at what was evidently a psychological moment, the first publication of its kind, it became an authority in clayworking industries throughout the world.

Mr. Randall organized the National Brick Manufacturers' Association and his record as Secretary of that organization for forty years and of never missing one of the annual conventions is one hardly to be equaled and shows his standing with his business associates. He also interested himself in finer ceramics and was instrumental in founding the ceramic school in Ohio and a National Ceramic Society. Mr. Randall's record shows him to have possessed initiative, foresight and executive ability of an unusual kind. These qualities added to an attractive personality and a kindly nature made him one of Indiana's notable citizens.

Message from the American Ceramic Society

Office of President
Woodbridge, N. J. July 31, 1926.

Mrs. THEODORE A. RANDALL
Indianapolis, Ind.

DEAR Mrs. RANDALL:

There is little that friends of your departed husband can do to assuage your sorrow and loneliness but we wish you to know in what esteem he was held and what value was placed on his services by members of the AMERICAN CERAMIC SOCIETY.

Few there are who have the combination of vision, personality and ability required for leadership and it is only a small percentage of these few who will give unstintedly of their time, resources, and vigor which leadership demands. What Mr. Theodore A. Randall accomplished as a pioneer leader in organizing the first and for several years the only association of ceramic manufacturers is a monument to his ability and liberality.

The National Brick Manufacturers Association was a very important factor in the establishment of the first collegiate instruction in ceramic engineering and in financing research fellowships. The Association made easier the organizaing of, first, the AMERICAN CERAMIC SOCIETY and later the several trade associations. The N. B. M. A. of which Mr. Randall as Secretary was the inspiring leader, advanced several years the developments which have been made in manufacturing methods, product and trade.

We, the members of the Board of Trustees of this SOCIETY, have a personal realization and as representatives of the members we wish to give expression to this realization of being beneficiaries in many respects of the vision and unselfish labors of Mr. Theodore A. Randall.

Although not an officer in this SOCIETY he made it pleasant and profitable for this SOCIETY in the early years to meet concurrently with the N. B. M. A. when this SOCIETY had very few members, small meeting attendance and sparse programs. Under these happy conditions this SOCIETY so grew in strength and in attendance at meetings and in programs that it was necessary for the two organizations to meet separately. During those early years Mr. Randall gave freely of his time and leadership.

His personality was winsome. His smile and handshake won friends and personal loyalities.

Mindful that Mr. Randall was a leader who accomplished, a friend who loved, a man who stood four square, a patriot with broad interests, and a humorist with a serious purpose, all of which he employed freely in building and maintaining an association for the promotion of ceramic research and education, we do hereby testify

of our appreciation of Mr. Theodore A. Randall as a man and as a leader among clay workers who were greatly benefitted and enriched by an unselfish use of his exceptional talents.

With deep personal regards and sympathy from members of the Board of Trustees and members at large of the SOCIETY.

Yours very truly,
ROBERT L. CLARE,
AMERICAN CERAMIC SOCIETY

The Common Brick Manufacturers Association of America

Just as this Bulletin was being mailed we received by telegram the information that Theodore A. Randall, Secretary of the National Brick Manufacturers' Association and publisher and editor of *The Clay-Worker*, had passed away on Friday night, July 23, at his home in Indianapolis. Mr. Randall underwent a serious operation which proved fatal.

Mr. Randall undoubtedly was the best known man to the brick fraternity in this country. Forty years ago he organized the first association of brick manufacturers, and it has held an unbroken series of annual meetings, which brought the manufacturers of the country together, built acquaintanceships, and proved of much educational value.

It is not too much to say that the organization of the various commercial associations, such as the National Paving Brick Manufacturers' Association, the American Face Brick Association, the Hollow Building Tile Association, and the Common Brick Manufacturers' Association, were furthered by the preceding effort of the N. B. M. A. Without the acquaintanceships and the spirit of coöperation and the benefits of educational work resulting from the older organization, it would have been much more difficult to organize the separate groups of the clay industry into the aggressive and defensive organizations that exist today.

The considerable credit that belongs to the N. B. M. A. reflects directly upon the personality of Theodore A. Randall, because from the beginning he has been the driving force and the head and the brawn of the N. B. M. A.

Also of credit to Mr. Randall are the many fine friendships which he has created throughout the clay fraternity.

His delightful family are as well known as himself, and to them we wish to extend, in behalf of the membership of the common brick group, our most sincere sympathy.

RALPH P. STODDARD,
SECRETARY-MANAGER

Estimates of T. A. Randall from our Charter Members

CHARLES F. BINNS: I met Mr. Randall first at Columbus in 1898 at the Convention which was the scene of the formation of the AMERICAN CERAMIC SOCIETY. I saw him in action at the sessions of the N. B. M. A. and was very much impressed by the grasp which he showed and by the way in which the members responded to his leadership. Our acquaintanceship since that time has been continuous, and most friendly. I esteemed him very highly as a man of affairs and I am sure that this feeling is shared by hundreds of men throughout the land.

Personally, I deeply regret his loss. He will be a difficult man to replace; the ceramic industries in general, and the brick making industry in particular, owe him an unpayable debt.

EDWARD ORTON, JR.: The world is bound to admire any man who deliberately applies himself heart and soul to an unselfish task. They may not agree with him, they may laugh at him, or oppose him, but if the work is an unselfish one, they are bound to admire

him. When the purpose is so patently for the public good as was Randall's in bringing the narrow, small minded, highly conservative old industry of clay working together and filling it with friendly coöperation and a broad kindly spirit of good fellowship, and when he consecrates himself to his task for a period of forty years—smiling, brave, untiring, through all kinds of changes and storms of public feeling, we all must recognize that in his passing, our loss is no ordinary one. We have lost an inspired leader. His place will not be filled!

While not a highly educated man, Randall had the vision to see the necessity of more education in clay working. While not a technical man or an engineer, he did not allow that to dim his perception of the need of more technical training and more engineering in clay working. While the word "research" was scarcely known when he went to college yet we find him actively pushing for research workers in colleges, government bureaus, and in the larger plants as they became able to afford them. In short, we find him backing everything that promised a sounder basis for progress in the field of clay working.

But he knew that after all, these things are but the tools of the craft. The thing that counts is the spirit of its workers. And in this field of human relations, as the inspirer, the encourager, the pacifier, the coöperator, his great service was rendered.

And as he lies now, wrapped in the peace of the ages, he looks back upon his work here and knows that it was good.

W. D. RICHARDSON: There are two classes of men who serve industrial associations,—those who freely contribute the knowledge they have gained from their practice and researches, and those who by their organizing and executive ability and their strong personality bring together men engaged in the same line of work and induce those who know to tell what they know and who disseminate the information thus brought forth. In the latter class Theodore A. Randall was preëminent.

Realizing forty years ago that progress in the brickmaking industry could best be promoted by the manufacturers coming together to discuss their problems, he organized the National Brick Manufacturers' Association. It was about this time that I entered the brickmaking industry. I attended the second convention and have missed only four conventions since then. At these meetings I formed some of the most valued friendships of my life, and of these Mr. Randall had the first place in my heart. His passing so suddenly from apparent health and an active life to the great and mysterious beyond was a shock to all of us. It is hard to realize that we shall never receive his cordial greeting again, that his sympathetic interest in our personal welfare and his friendly counsel have gone from us forever.

No man in America had so many friends in the brickmaking industry as Mr. Randall. To have friends one must be friendly, and it has been said of Randall that he "simply radiated friendship." But his wonderful personality and his forceful character brought the inevitable criticism and opposition.

Mr. Randall was so devoted to the N. B. M. A. that he could not look with composure on the breaking of so many from its membership into separate branches, forming independent associations and neglecting the parent organization. But this was inevitable and was not a discredit to him. He believed that the brick manufacturers should still support the N. B. M. A., the aims and purposes of which did not conflict with the commercial associations. The expansion of the AMERICAN CERAMIC SOCIETY and the formation of a special section for those interested in the manufacture of heavy clay products captured the younger men, especially those of technical training. Randall's personality and his exceptional ability to conduct conventions failed to reach these men and the older men passing away, together with the determined and systematic opposition of a few rivals, naturally caused a gradual dwindling of membership in the N. B. M. A.

Randall accomplished his mission and the influence of his work will continue to contribute to the advancement of the brickmaking industry. His career presents many useful lessons, a study of which should be an inspiration to his followers. He did a noble work for the clay industries in many ways and in the early years of the AMERICAN CERAMIC SOCIETY worked jointly with Orton in arrangements for its annual meetings with the N. B. M. A. Therefore, it is fitting that our *Journal* pay him tribute.

We had not thought, dear friend, that you would go so soon, but it will not be long till we follow and others take our places.

A. V. BLEININGER: The departure of a figure so prominent in the clay industry as was Theodore Randall moves many of us to pay him our last tribute. There can be no doubt but that his chief accomplishments in life were threefold in character. He was first to establish ceramic journalism in this country. He was first to found a national association of clay products manufacturers in the United States. And, third, he was first to link together association work with technical investigation. These are achievments of no mean kind and there might be added others as well.

Theodore Randall had the gift of attracting men and of setting them to work, for their mutual benefit. His was a positive personality, unswervingly loyal to his cause and his friends, the predominating characteristic of a leader, and with the will to fight for his convictions to the bitter end. Personally he was most lovable, tolerant, kind and generous. Once his affections were won he gave to the limit. Those of us who knew him will never forget him. In our hearts his memory will ever be one of the fine things that will remain with us.

S. GEIJSBEEK: In the passing of Theodore A. Randall the clayworking industry has lost one of its most ardent supporters. In my thirty years' friendship with Randall he proved to be one of the most sincere friends I ever had.

DOUGLAS F. STEVENS: I consider that Mr. Randall's death is a very great loss to the clayworking industry. I have known him personally for nearly twenty years. The persistent effort and unfailing enthusiasm which he put into his work as Secretary of the National Brick Manufacturers' Association as well as his influence as Editor of *The Clayworker* have made a very great contribution in the promotion of friendliness and good will and the development and spread of improved ideas and methods, all of which have exerted great influence in improving and developing our industry.

A. S. WATTS: In the death of my friend T. A. Randall, the ceramic profession and the ceramic industries have lost one of their most loyal supporters.

I have lost a most esteemed friend.

In my 25 years' acquaintance with Mr. Randall, I have found him always ready and glad to render helpful service even though the requests were often unreasonable. His friendly council and encouragement will be a great loss to me and his memory will always be an inspiration.

W. D. GATES: Randall has passed on. I cannot yet sense it. He was so vigorous, so bubbling over with good cheer, that it had never occurred to me that I would survive him. Memories of his activities among the clay workers, of the great results accruing from those labors, crowd upon me. He has left his mark to the good of the craft, strongly impressed, and his work will last long and stand strong in the history. I am too late to write you properly as well as too dazed to properly express myself.

PROPOSED BY-LAWS OF THE GLASS DIVISION OF THE AMERICAN CERAMIC SOCIETY

I. Officers The officers of the Division shall consist of a chairman, vice chairman and secretary. They shall serve for one year and shall be installed by the retiring officers at the last session of the Annual Meeting of the SOCIETY.

The duties of these officers shall be those usually assigned to such officers. They shall constitute, with the Divisional Trustee, the Executive Committee of the Glass Division, over which the Divisional chairman shall preside. The Divisional chairman shall appoint representatives on the general committee of the SOCIETY, except the Board of Trustees. When necessary the Executive Committee shall appoint a new vice chairman or secretary to fill an unexpired term.

II. Nominating Committee The Nominating Committee of three members shall be appointed by the chairman.

III. Duties of Nominating Committee (*a*) *Division officers.* The Nominating Committee shall nominate one person for each office of chairman, vice chairman, secretary, and, when necessary, trustee. This ballot shall be submitted to the members of the Division during the first regular meeting of the Division and voting shall be on the second day during the business meeting.

Ten members of the Division can make a nomination by sending a formal petition to the Chairman of the Division at the first regular session of the Division at the Annual Meeting of the SOCIETY.

(*b*) *Trustee.* When a trustee from the Glass Division is to be elected, the Nominating Committee shall submit a ballot to the members of the Division in time for their return for report to the General Nominating Committee.

IV. Committees The Standing Committees of the Division shall be Research, Standards, Data, Membership, Rules, Education, Papers and Program.

The chairman of each of these committees shall be appointed by the chairman of the Division and he may appoint the individual members of the committee. The chairman of the committee shall act as a Division representative on the SOCIETY's general committee. All committeemen shall hold office for the term for which the Divisional officers have been elected, except the Standards, Data, and Research Committees, which shall consist of 3 members each, one of whom shall be appointed each year to serve for 3 years.

Each committee chairman shall prepare a written report of the committee's activities during the year to be presented at the business session of the Glass Division at the Annual Meeting. The report should be handed to the Chairman before the meeting so due time allowance can be made for all reports.

V. The Chairman shall prepare a report which shall be presented at the business meeting at the end of the year on the activities of the Division during the year. This shall be published in brief form in the *Bulletin*.

VI. The secretary shall report in the first issue of the *Bulletin* after the Annual Meeting, the proceedings of the Division at the meeting.

VII. Any such portion of these laws which do not conflict with the laws of the SOCIETY shall be valid.

VIII. These laws may be amended by a two-thirds vote of the Section as follows: A petition by 20 members to the Chairman calling for a vote on amendment to by-laws ninety days before the Annual Meeting. The Secretary shall submit ballots to the membership at least sixty days before the Annual Meeting. Any ballots returned before the business session at the Annual Meeting shall be counted. A two-thirds majority of the membership shall be necessary to carry an amendment.

IX. The accumulated files of the officers and committee chairmen of the Division shall be sent to the central office of the SOCIETY for safe keeping at the end of their term of office, to be readily available for reference for incoming officers.

PROPOSED BY-LAWS OF WHITE WARES DIVISION OF THE AMERICAN CERAMIC SOCIETY

I. Officers The officers of the Division shall consist of a chairman and a secretary. They shall serve for one year and be installed by the retiring officers at the Annual Meeting of the SOCIETY.

The duties of these officers shall be those usually assigned to such officers. The chairman shall appoint representatives on the general committees of the SOCIETY, except the Board of Trustees. The secretary shall act as vice chairman, and when necessary shall appoint a new secretary to fill his unexpired term.

In case the secretary becomes incapacitated, the chairman shall appoint one to fill the unexpired term.

II. Nominating Committee This committee shall be appointed by the new chairman as soon as possible after the Annual Meeting of the SOCIETY. It shall consist of three members, no two of whom shall represent the same branch of the white ware industry.

The chairman of the Nominating Committee shall be the White Ware Division's representative on the General Nominating Committee of the SOCIETY.

III. Duties of Nominating Committee (*a*) *Division officers.* It shall be the duty of the Nominating Committee to make two nominations each for the office of chairman and secretary of the Division. They shall announce nominations 120 days before Annual Meeting. They shall submit a ballot to the members of the Division at least 60 days prior to the Annual Meeting. This ballot shall contain the nominees for chairman and secretary.

Twenty members of the White Wares Division may place an additional name in nomination by sending a formal petition to the chairman of the Division at least 90 days before the annual meeting.

Only such ballots as are returned prior to the Annual Meeting shall be counted. The Division chairman shall appoint a tellers' committee at the said Annual Meeting, who shall count the ballots and declare the candidates receiving the highest number of ballots for their respective offices elected.

(*b*) *Trustee.* On the year in which the trustee from the White Wares Division is to be elected, the Nominating Committee shall place in nomination two names for this office. They shall submit a ballot to the members of the Division not later than July 1st. These ballots are to be returned to the said committee not later than August 1st. The committee shall examine said ballots and report to the General Nominating Committee of the SOCIETY, the candidate receiving the highest number of votes, such candidate to be the nominee from the White Wares Division to appear on the ballot of the SOCIETY.

IV. Only such portion of these laws which do not conflict with laws of the SOCIETY shall be valid.

V. These by-laws may be amended by a ⅔ vote of the section according to following procedure:

Twenty members may petition chairman to call for vote on amendment to by-laws 90 days before the Annual Meeting of the SOCIETY. The Secretary shall submit ballots to membership at least 60 days before Annual Meeting. Only such ballots as are returned prior to meeting shall be counted. A ⅔ majority shall be necessary to carry the amendment.

PACIFIC-NORTHWEST SECTION

Combined Summer Meeting of the Pacific Northwest Section of the Society with the Pacific Northwest Brick and Tile Association

Over 50 persons from various portions of Oregon, Washington, and British Columbia gathered as guests of the Clayburn Co., Ltd., for a two-day summer meeting, July 16 and 17, 1926. J. H. Roaf, managing director, with the help of J. S. Burns, sales manager, and J. W. Ball, superintendent of plants, was awaiting the group with a corps of able assistants to serve the famished tourists from the States with refreshments.

After an inspection of the Clayburn plant, all climbed aboard the company's electric railway to the mines for 3½ miles up Sumas Mountain and past the various mine openings. The party saw the Kilgard plant where sewer pipe are being made by compressed air instead of steam.

In the evening the visitors were led by auto caravan to Vancouver, and to the headquarters of the meeting, the Elysium Hotel. Golf, shopping and sightseeing occupied Saturday morning. Saturday afternoon brought the technical session with the following papers:

1. *W. J. Howard.* "Brick as a Building Material—Factors Affecting Its Strength—Summary of Test Data." Mr. Howard made a correlation of the strength, absorption, fire resistance, relation between wall and individual brick strength and pointed out the necessity of a more uniform product in order that engineering data can be compiled for use by architects and in the revising of building codes.

2. *Hewitt Wilson.* "Preliminary Results of Efflorescence Tests of Various Mortars and Brick Panels." This was a progress report of the coöperative work between the P.N.W. Brick and Tile Association and the University of Washington in a study of the scumming of various mortar materials which are being used with local brick. Saturated brick at the time of laying, salt water sand, and a content of Portland cement in the brick have been shown to be the worst scum producing factors found in these tests.

3. *H. N. Baumann, Jr.* "A Description of a New Brown Recording CO_2 Apparatus." Mr. Baumann described the principles of the new apparatus recently purchased by the ceramic engineering department at the University of Washington for continued work in the testing of the efficiency of various local kilns.

4. *Kenneth Johnson.* "Comparison of Laboratory and Commercial Kiln Tests." This is a report of the comparison in degree of vitrification between the same clays fired to the same cone in commercial kilns with long soaking periods and laboratory kiln of rapid rise and fall in temperature. The results indicate that a quick firing to a given cone produces a higher degree of vitrification than a slow firing to the same cone.

5. *H. N. Baumann, Jr.* "Progress Report of the Heat Balance of Continuous Kilns." Mr. Baumann has been studying the efficiency of a number of the local Hoffman continuous kilns and will be able to draw a number of interesting comparison with other types of kilns.

6. *Hewitt Wilson.* "Effect of Addition of Common Salt to Glacial Clays." Mr. Wilson reported upon the results of some class work at the University of Washington. Common salt darkens the color, tends to eliminate the scum and slightly increases the strength of the local glacial clays.

NOTES AND NEWS

CHICAGO ENAMELERS MEET

At the June Meeting of the Chicago Enamelers Club Robert C. Boyd of the Chicago Hardware Foundry Company gave a talk on "Ground Coats for Cast Iron."

After a general résumé of grip coat literature, Mr. Boyd gave a few facts regarding operations at his plant. The frit is smelted to a smooth glass and is fractured by running the molten frit into cold water. It is dried with the aid of waste heat and milled with 15% clay and 50% water. The smelting time required is about 3 hours for a 500-pound melted batch and the enamel is milled until it passes 150-mesh. The slip should be about 54–58° Baumé for best slushing. A coat of this consistency will not be too thin or too thick.

The clay content of this enamel is high but it is very intimately mixed and therefore becomes thoroughly fused with the batch. Care must be taken that the ground coat is not too coarse or it will pit and if slushed too heavy it will pinhole. Cobalt and manganese help to make a ground coat grip better and tend to cure chipping in a low silica iron. The fact remains that very few sanitary plants use cobalt in the ground.

Manganese is a good material for a batch which is to be sintered. It has a tendency to keep the batch spongy and in this condition it is easier to break up.

Mr. Dvorak of the Crown Stove Company stated that in Germany ground coats are smelted down in a regular fritting furnace and the hot mass is then fractured by a stream of water played upon it. It is necessary to crush the mass before it is milled. These grounds are low in fluxes and never blister. High flux grounds are fired twice in the furnace to insure the removal of all blisters. Enamel that is not smelted enough will often pinhole.

Albert Vodika of Aetna Porcelain stated that the clay content in a ground mill varies as much as 2 to 20%. In firing a grip coat with high clay content the furnace must be hot, otherwise the enamel will chip off. J. A. DeCelle of Chicago Hardware Foundry stated that a high clay ground coat does not rub off and works very well in dipping.

Mr. Menns of the Peoples Gas Light and Coke Company stated that crazing can be stopped by the addition of a little raw sand to the mill. After the sand is added the mill should be turned over for about one hour. For dry enameling he stated magnesium carbonate is a good flocculent to use.

J. A. DeCelle is acting chairman of the Club in the absence of Bruce Wagner who has moved from this immediate territory.

A. S. T. M. C-8 COMMITTEE

G. A. Bole, Columbus, Ohio, has been appointed Chairman of Committee C-8, American Society for Testing Materials. Louis J. Trostel of Baltimore, Md., is Secretary of the same Committee.

RESEARCH FELLOWSHIPS IN CERAMICS AND MINERALOGY

The Engineering Experiment Station of Ohio State University announces that one of the fellowships which it offers for the coming year in cooperation with the Columbus Station of the Bureau of Standards, is unfilled. Graduates with the equivalent of a B. S. degree, proper training in ceramics, physical chemistry and an elementary course in crystallography and mineralogy are eligible. The income for the fellowship is $750 per annum. Applications should be sent in at once to Dean E. A. Hitchcock, Engineering Experiment Station, Ohio State University, or Samuel J. McDowell, Superintendent, Columbus Branch, Bureau of Standards, Columbus, Ohio.

CALENDAR OF CONVENTIONS

AMERICAN CERAMIC SOCIETY		
Summer Meeting	Aug. 30–Sept. 2, 1926	Philadelphia, Pa.
Annual Meeting	Feb. 14–19, 1927	Detroit, Mich.
Amer. Assn. Advancement of Sci.	Dec. 27, 1926–Jan. 1, 1927	Philadelphia, Pa.
Amer. Chemical Society	Sept. 6–11, 1926	Philadelphia, Pa.
Amer. Electrochemical Society	Oct. 7–9, 1926	Washington, D. C.
Amer. Engineering Council	Jan., 1927	Washington, D. C.
Amer. Foundrymen's Assn.	Sept. 27, 1926	Detroit, Mich.
Amer. Gas Assn.	Oct. 11–14, 1926	Atlantic City, N. J.
Amer. Institute	Oct. 18–30, 1926	New York City
Amer. Inst. Min. and Met. (General Meeting)	Oct. 6–9, 1926	Pittsburgh, Pa.
Amer. Inst. Min. and Met. Engrs. (Annual Meeting)	Feb. 14–17, 1927	New York City
Amer. Mining Congress	Dec., 1926	Washington, D. C.
Amer. Soc. Mech. Engrs.	Sept. 27–30, 1926	Richmond, Va.
(Spring Meeting)	May 23–26, 1927	White Sulphur Springs, W. Va.
Amer. Soc. for Steel Treating	Sept. 20–24, 1926	Chicago, Ill.
Assn. Sci. App. Makers	April, 1927	?
Congress of Amer. Industry	Sept. 7–24, 1926	Philadelphia, Pa.
English Ceramic Society	Sept. 16–17, 1926	Leeds, England
Glass Container Assn.	April or May, 1927	?
The Gypsum Industries	Dec. 1926	Chicago, Ill.
Hollow Building Tile Assn.	Feb. 1927	Chicago, Ill.
Natl. Academy of Sciences	Nov. 8–10, 1926	Philadelphia, Pa.
Natl. Assn. of Mfrs.	Oct. 20–22, 1926	New York City
Natl. Assn. of Mfrs. of Pressed and Blown Glassware	March 8, 1927	Pittsburgh, Pa.
Natl. Exposition of Power and Mech. Eng.	Dec. 6–11, 1926	New York City
The Natural Gas Assn. of Amer.	May, 1927	Cincinnati, Ohio
Natl. Safety Council	Oct. 4–9, 1926	Detroit, Mich.
Ohio Ceramic Industries Assn.	Oct., 1926	Columbus, Ohio
Optical Society of America	Oct. 21–23, 1926	Philadelphia, Pa.
Society of Glass Technology (Eng.)	Oct. 20, 1926	Sheffield, England
	Nov. 17, 1926	Leeds, England
	Dec. 15, 1926	London, England
Stained Glass Assn. of Amer.	June, 27, 1927	St. Louis, Mo.
Taylor Society	Dec. 8–11, 1926	New York City

Transactions Desired

Volumes 5, 7, 8, 9, 10, 12, 15, 18 and 19 of the Transactions of the American Ceramic Society are out of print. $5.00 will be paid for each copy on receipt in the Secretary's office.

Journals Urgently Needed

The June, 1923, January, February, 1924, January, 1925, and January, 1926, issues of the Journal are also out of print; 60 cents will be paid for each copy.

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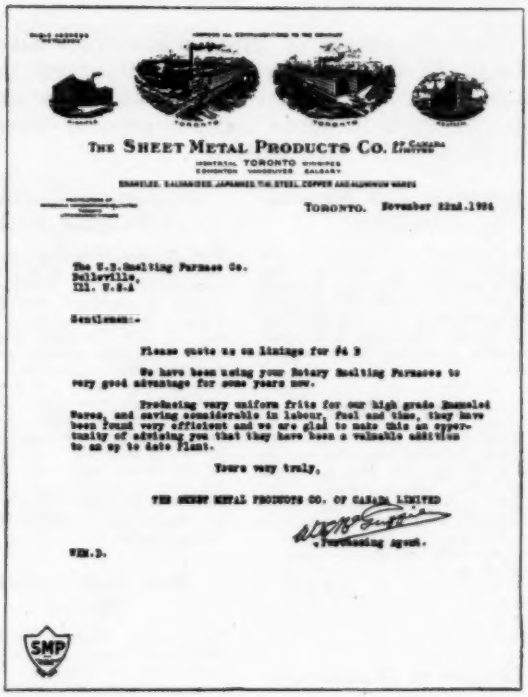

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Georgia Clays for Paper Fillers.

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Use of Sedimentary Kaolins of Georgia in Whitewares.

Kaolin and Refractory Clay Deposits in Wilkinson Co., Ga.

Utilization of Georgia Kaolins in the Manufacture of Face Brick.

Distribution of Kaolin and Bauxite of the Coastal Plain of Georgia.

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Thus far, tests of brick made from Georgia Kaolin have proved from 29 to 220 percent better than silica and special fireclay brick for use in electric steel furnaces and 266 percent better in openhearth furnace ladles.

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The supply of Kaolin in the Coastal Plain of Georgia along the Central of Georgia Railway is sufficient to meet the needs of the refractory industry for over 600 years. Deposits here cover an area of about 10,000 square miles.

Easy to Mine

Unlike fireclay deposits, Georgia Kaolin is found near the surface where it can be mined at low cost with steam shovels. Deposits run from 10 to 40 feet in thickness with little or moderate overburden. It is estimated that raw material in quantity can be mined at a cost of from 30 to 40 cents a ton as compared to an approximate cost of $1.50 to $2.00 a ton where underground mining is necessary.

Cheaper to Manufacture

Kaolin refractory brick is made of one clay, thus making it unnecessary to assemble two or more materials from widely separated sources—an economic advantage of great importance when considering the cost of production. Then too, power is reasonable and labor is plentiful.

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The average weight of standard sized kaolin brick is 6½ lbs. as compared to 7 lbs. average weight of standard sized fireclay brick. This alone means a saving of 500 lbs. per thousand brick—an item which reduces freight costs materially. Then, too, freight rates are favorable and finished brick can be shipped either by rail or water to points of consumption. Freight service by rail is maintained to all points in the north and west through the principal gateways. Steamship service from Savannah to all important coast cities and foreign ports.

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The use of Georgia Kaolin for refractory brick is a comparatively new development. There is abundant opportunity to establish a large and prosperous industry here. Many desirable undeveloped properties are available. The Central of Georgia Railway has made a careful survey of deposits in this territory and is in position to furnish valuable suggestions to those interested.

Central of Georgia Railway

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Gen'l Industrial Agent

CENTRAL GEORGIA

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Pennsylvania Salt Mfg. Co.
Roessler and Hasslacher Chemical Co.

Aloxite (Refractory Products)
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Alundum (Refractory Products)
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Chambers Brothers Co.

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Automatic Cutters
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Automatic Stove Rooms
Philadelphia Drying Machinery Co.

Automatic Temperature Control
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Leeds & Northrup Co.

B

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Alsing, J. R. Eng. Co.

Ball Mills
Alsing, J. R. Eng. Co.
McDanel Refrac. Porcelain Co.
Mueller Machine Co., Inc.

Batts
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Norton Co. *("Alundum-Crystolon")*

Bench Whirlers
Cain Machine Co

Bitstone
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Potters Supply Co.

Bituminous Coal
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Norton Co. *("Alundum-Crystolon")*.
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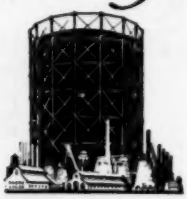

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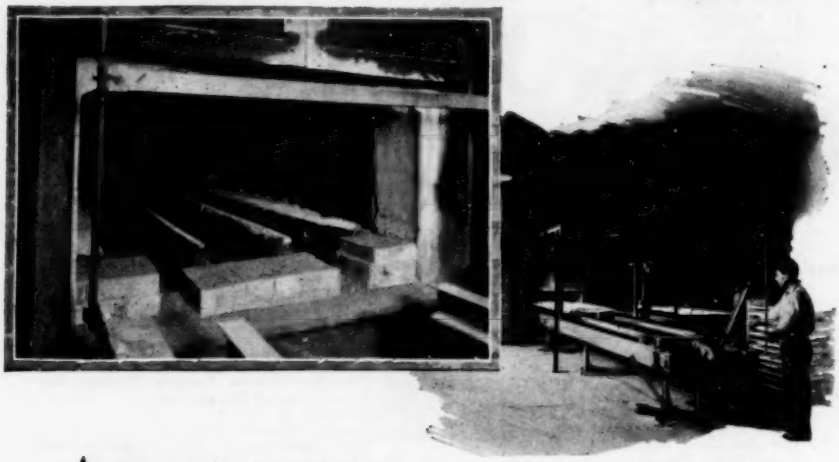

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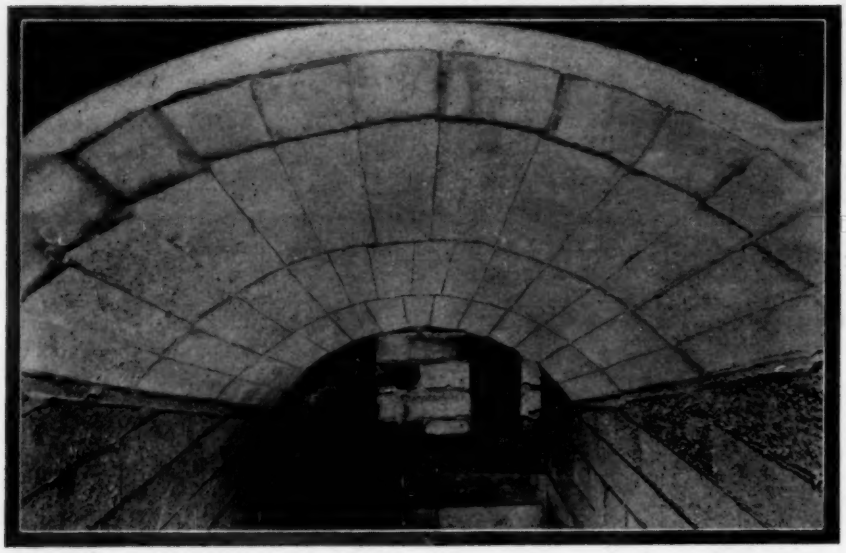

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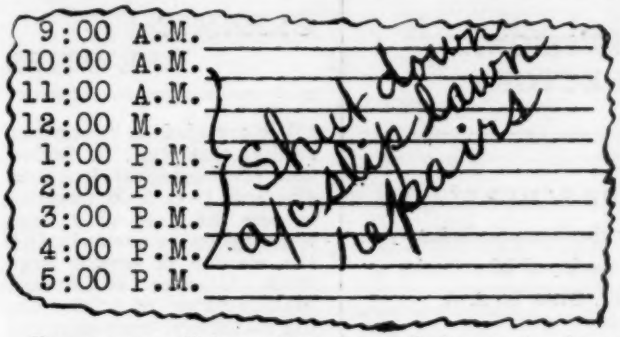

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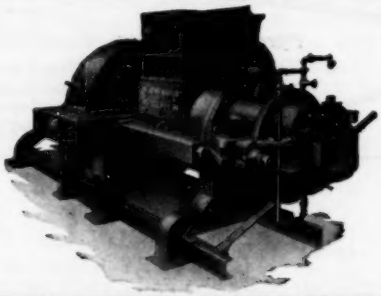

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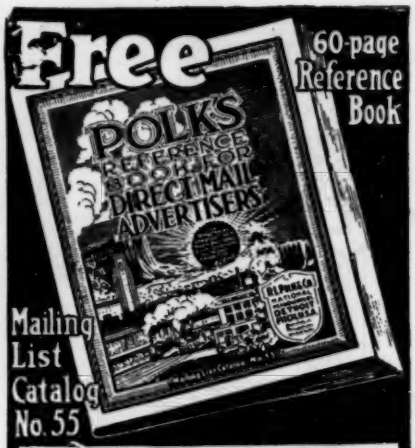

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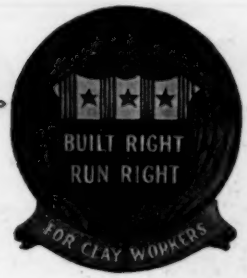

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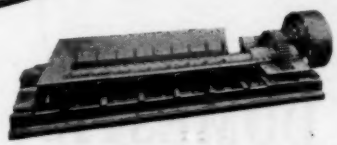

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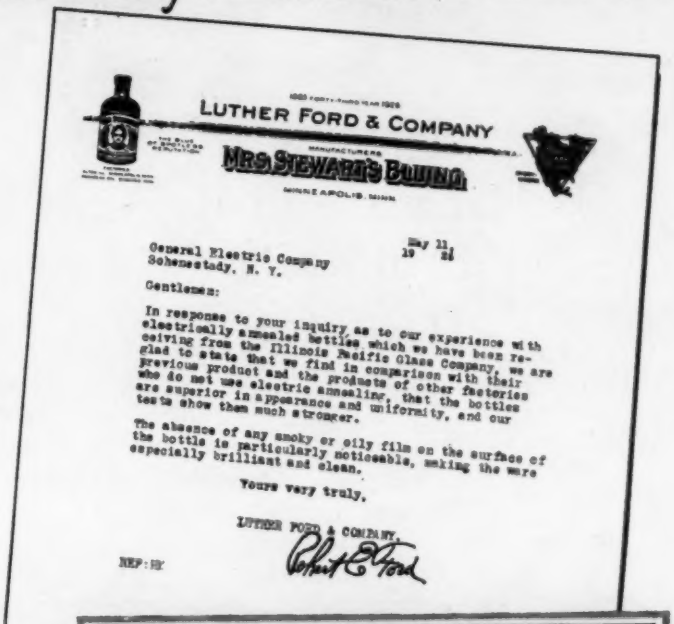
American Ceramic Society

2525 N. High St. Columbus, Ohio

Customers Appreciate Electrically Annealed Bottles



LUTHER FORD & COMPANY

MRS. STEWART'S BLUING

MINNEAPOLIS, MINN.

May 11, 19 21

General Electric Company
Schenectady, N. Y.

Gentlemen:

In response to your inquiry as to our experience with electrically annealed bottles which we have been receiving from the Illinois Pacific Glass Company, we are glad to state that we find in comparison with their previous product and the products of other factories who do not use electric annealing, that the bottles are superior in appearance and uniformity, and our tests show them much stronger.

The absence of any smoky or oily film on the surface of the bottle is particularly noticeable, making the ware especially brilliant and clean.

Yours very truly,

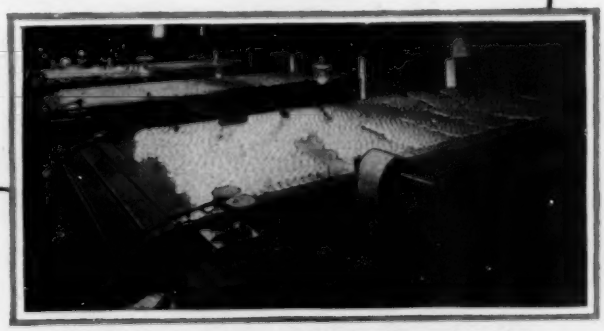
LUTHER FORD & COMPANY,

REF: HF

Robert E. Ford

Although electric heat will not supplant all other forms of heat for industrial purposes, there are processes in every industry where it is the ideal heat—the most economical heat—the heat that ultimately will be used.

ULTIMATELY ELECTRIC HEAT IN EVERY INDUSTRY.



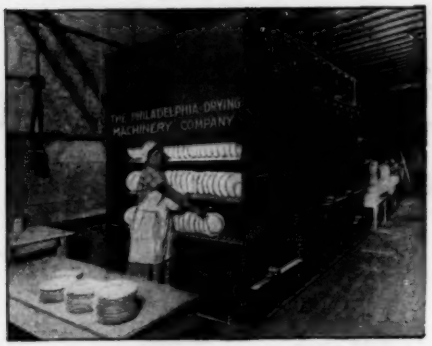
The Illinois Pacific Glass Company uses electrically heated lehrs exclusively—and all of them are equipped with General Electric heating units and automatic control.

570-18C

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., SALES OFFICES IN PRINCIPAL CITIES

Improved "HURRICANE"



Automatic MANGLE

Of Many Good Reasons For Using "HURRICANE" Dryers

Here Are Three

Capacity Guarantee. For over a quarter of a century we have guaranteed the capacity of "HURRICANE" Dryers—guaranteed conservatively. Capacity is usually greater than guaranteed, a compliment to the user's selective judgment, an insurance against peaks in production.

Air Circulation. Consistent care is given to the even distribution of the drying air, so that drying uniformity approaches perfection. To the user this means a better product at lower cost.

Improved Conditions. Fire-proof construction is combined with an improved system of "HURRICANE" insulation that keeps the heat in the dryer—away from the operators.

Other Good Reasons Will Develop When You Investigate

THE PHILADELPHIA DRYING MACHINERY COMPANY

Stokley St. above Westmoreland, Philadelphia, Pa.

Canadian Agents:
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Montreal

HURRICANE
Ideal Drying Every Day

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He says, "We selected the Pemco Fork because we could get larger production from it—and because it has no overhanging structure which is bound to gather dirt—which dirt will later drop on unfired ware about to enter furnace and consequently injure the quality."

The Pemco Fork like all other Pemco Equipment and Pemco Enamels is specifically designed for one purpose—Quality and Quantity Production at minimum costs.

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THE PORCELAIN ENAMEL & MFG. CO.

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